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EFFECT OF MAGNETISATION ON ACID—AND ALKALINE PHOSPHATASES IN THE DEVELOPING SILK GLAND OF *BOMBYX MORI* (L.)

ALKA K. CHOUGALE & NARSIMHA K. MORE
Department of Zoology, Shivaji University, Kolhapur, India 416004

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Effect of magnetisation on acid– and alkaline phosphatases in the developing silk gland of *Bombyx mori* (L.) was investigated. Acid phosphatase showed an increasing trend during silk gland development and opposite was the case with alkaline phosphatase. The trends were more pronounced in the pure races than in their hybrids. The results are discussed in relation to the development of silk gland and silk production.

(*Key words*: *Bombyx mori*, silk gland, acid phosphatase, alkaline phosphatase)

INTRODUCTION

In order to increase the silk yield efforts were made to study the effects of temperature (VERMA & ATWAL, 1967), light (AKHANDOV & ZEINALOV, 1968), photoperiod (JOLLY *et al.*, 197$_1$), x-rays (KANAREV & CHAM, 1985), gamma rays (SHIGEMATSU & TAKESHITA, 1968) and artificial diets and amino acids (IWANRAT & ONO 1969) on the development of the silkworm *B. mori*.

Magnetisation has increased seed germination (PITTMAN, 1965), crop production (TODORON *et al.*, 1966) and has changed cotton fibre characters (KALANTROV & MELIKOVA, 1973). LUCA and his associates (LUCA *et al.*, 1967) initiated studies on the silk prodution after exposure of the larvae to the magnetic field. Their studies, however, are inconclusive. Enzymes of the protein synthesis have been analysed by HELLER & JOZEWSKA (1959). SHRIDHARA & BHAT (1963) have studied acid– and alkaline phosphatases in the silk glands of *B. mori*. Quantitative changes in the acid phosphatase occurred after magnetisation of mouse at cellular level (CONELY *et al.*, 1966). Structural changes in the enzyme molecule has been reported after magnetisation (YOUNG, 1969). Recently CHOUGALE & MORE (unpublished data) have obtained an increase in the silk proteins in the magnetised larvae.

This communication reports the effects of magnetic field on acid—and alkaline phosphatases in the developing silk glands of different strains of *B. mori*.

MATERIALS AND METHODS

Pure 'NB4D2' and 'PM' races of *B. mori* and their hybrids ('NB4D2' × 'PM') and ('PM' × 'NB4D2') were used in this investigation. The quality disease free layings (DFLs) were obtained from the Government Graniage Centre at Gadhinglaj (Dist.: Kolhapur). Incubation of the eggs and rearing of larvae was done as per the regimen of KRISHNASWAMI *et al.* (1973). The larvae from each DFL were divided into an experimental and a control group. The larvae of

Address for communication : Dr. N. K. More, Department of Zoology, Shivaji University, Kolhapur-416 004.

each variety were magnetised in bulk, by placing them in a perforated plastic container. It was suspended between the two poles of axial electromagnet (EM-50) at a strength of 3500 G. The larvae once exposed were not exposed again during their remaining larval life. Upto fourth instar, the exposure was done for 20 min daily for the entire larval period of each stage. The fifth instar larvae were exposed daily for 20 min for the first three days, immediately after the fourth ecdysis. Acid- and alkaline phosphatases were determined on fifth day of the fifth instar larvae employing the LINHARDT & WALTER (1965) method and proteins were determined by using LOWRY'S method (LOWRY *et al.*, 1951).

OBSERVATIONS

Variation in the acid phospatase activity due to exposure of larvae to magnetic field are indicated in Table 1. The enzyme activity increased after magnetisation. The increase was not similar for all the experimental groups and for all the strains studied. Highest activity occurred in the first instar and lowest in fifth instar control larvae of all the strains. A similar trend was exhibited by the exprimental larvae. However, a minimum activity occurred in the second instar magnetised larvae. The percent increase exhibited an increasing trend in the experimental larvae. The first instar magnetised 'NB4D2' larvae showed 54.21 % increase and in the final instar, it was 128.25%. For the 'PM' strain, the respective figures were 47.00% and 107.89%. In the 'PM' × 'NB4D2' the increase was 46.65% in the first instar larvae and was 93.44 % for the final instar larvae. The corresponding figures for 'NB4D2' × 'PM' were 32.62 % and 89.19%. Changes in the alkaline phosphatase activity are presented in Table 2. A decrease in the enzyme activity was obtained in the larvae exposed to the magnetic field. It was, however, not uniform, both instarwise and strainwise. The highest activity was seen in the fifth instar control larvae and the lowest in the third instar larvae. In the magnetised larvae, the highest activity was seen in the second instar larvae. The percent decrease however, showed a steady increasing trend. In the first instar larvae of 'NB4D2' the percent reduction was 38.95% and was 79.54% in the fifth instar. The respective figures PM were 30.00 % and 75.81 %. The percent reduction in the first instar larvae of 'PM' × 'NB4D2' were 32.12% and 27.05%. The values for their fifth instar larvae were 67.98% and 62.00% respectively.

DISCUSSION

The results obtained indicate that an exposure of the silk worms to the magentic field changes the acid- and alkaline phosphatase activity in their silk glands. This is true for all the strains studied presently. However, the changes in both the enzymes are not similar. The activity of acid phosphatase was enhanced while that of the other enzyme got reduced. Acid phosphatase occurs in higher concentration than alkaline phosphatase in the silk glands. SHRIDHARA & BHAT (1963) have obtained similar results. The silk glands start the synthesis of silk proteins at about day 10 of the embryonic life (PRUDHOMME *et al.*, 1985). They are secreted into the lumen of the gland and the same are spun at the end of each intermoult. The growth of the silk gland cells and the production of silk are stopped at each moulting. This continues till the spinning of the cocoon begins (PRUDHOMME *et al.*, 1985). EID *et al.* (1989) have supported the above view. There is a heavy accumulation of RNA at the middle of the last instar (PRUDHOMME *et al.* 1985). It is also claimed that an increase in the silk production is a consequence of an increase in the cellular activity (EID *et al.*, 1989). Thus, at this stage the biosynthetic

TABLE 1. Effect of magnetic energy on silk gland acid phosphatase activity (μg *p*-nitrophenol liberated/h/mg protein).

Sr. no.	Race	1st instar		2nd instar		3rd instar		4th instar		5th instar	
		C	E	C	E	C	E	C	E	C	E
1.	NB4D2	55.326 ±1.326	85.320 ±0.580 (54.21)	38.400 ±1.383	61.937 ±1.572 (61.29)	42.136 ±0.589	78.409 ±0.717 (86.09)	39.205 ±2.007	77.396 ±1.122 (97.41)	33.084 ±0.697	79.482 ±1.039 (128.15)
2.	PM	50.006 ±1.099	73.509 ±0.996 (47.00)	35.341 ±1.346	54.132 ±1.068 (53.17)	36.803 ±1.307	65.701 ±1.722 (78.52)	38.325 ±0.624	73.289 ±1.023 (91.23)	34.847 ±1.022	72.443 ±0.530 (107.89)
3.	PM × NB4D2	49.534 ±1.341	69.670 ±0.670 (40.65)	40.234 ±1.349	59.571 ±1.361 (48.06)	39.387 ±0.898	67.017 ±0.672 (70.15)	40.420 ±0.806	74.304 ±0.649 (83.83)	37.922 ±0.802	73.356 ±1.115 (93.44)
4.	NB4D2 × PM	53.554 ±0.958	71.023 ±1.175 (32.62)	40.770 ±1.257	61.155 ±1.360 (50.00)	45.273 ±1.308	71.848 ±0.868 (58.07)	39.334 ±1.457	69.400 ±0.656 (76.44)	38.640 ±0.468	73.103 ±0.598 (89.19)

TABLE 2. Effect of magnetic energy on silk gland alkaline phosphatase activity (μg *p*-nitrophenol liberated/h/mg protein).

1.	NB4D2	6.676 ±0.649	4.076 ±0.756 (38.95)	8.438 ±0.896	4.436 ±0.725 (47.43)	2.333 ±0.479	0.813 ±0.254 (61.15)	5.530 ±1.565	1.437 ±0.645 (74.02)	13.574 ±0.609	2.775 ±1.205 (79.54)
2.	PM	5.443 ±0.847	3.810 ±0.408 (30.00)	6.197 ±0.673	3.656 ±0.685 (41.00)	2.200 ±0.509	0.884 ±0.308 (59.82)	4.824 ±1.237	1.555 ±0.770 (67.99)	9.755 ±1.418	2.360 ±1.473 (75.81)
3.	PM × NB4D2	6.009 ±1.245	4.079 ±0.576 (32.12)	7.320 ±1.057	4.520 ±0.513 (38.25)	2.056 ±0.521	1.000 ±0.494 (51.36)	4.973 ±1.287	2.150 ±1.141 (56.77)	10.420 ±1.462	3.337 ±0.742 (67.98)
4.	NB4D2 × PM	7.882 ±1.729	5.750 ±1.192 (27.05)	8.615 ±0.509	5.578 ±1.062 (35.25)	3.527 ±0.972	1.880 ±0.793 (46.70)	5.427 ±1.337	2.281 ±1.429 (57.97)	13.748 ±1.197	5.224 ±1.557 (62.00)

C = Control. Values in parenthesis are the % increase in the experimental of Table 1 and % decrease in the experimental of Table 2.
E = Experimental. Values are mean of 3 replications ± SD, 5 larvae in each group.

activities are at their peak and almost all of them are directed towards the silk synthesis. ALEXANDER & GANESHAN (1990) put forward a view that the enzymatic reactions in the living systems are influenced by the magnetic field. This they have attributed to the occurrence of paramagnetic molecules and free radicals in the system. One of the influences of magnetic field on the living system is triggering of an enzymatic activity (AKOYUNOGLOU, 1965). ALEXANDER & GANESHAN (1990) has indicated an enhancement in the metabolic efficiency after the application of magnetic field.

The enhancement in the activity of acid phosphatase is optimum at the last instar stage and the same has resulted in an increase in the silk proteins and the silk production (CHOUGALE & MORE, unpublished data). The increase in the enzymatic activity of the silk glands is a reflection of increased biosynthesis of the protein (EID et al., 1989). Acid phosphatase also has a role in the silk production and its increased activity due to magnetisation might have increased the silk synthetic capacity further. Administration of urea has promoted the enzymatic activity of silk glands as well as silk proteins (LIM & ZHU, 1985; EID *et al.*, 1989). Thus, the optimum activity of the acid phosphatase during the fifth instar stage has a relevance to the process of silk synthesis and its production, particularly during this stage and if the larvae are magnetised, there would be a further increase in the productivity of silk.

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ELECTROPHORETIC STUDIES ON THE DEFENSIVE SECRETIONS OF *PHEROPSOPHUS* SPP. (COLEOPTERA: CARABIDAE)

D. RAJAGOPAL & P. BASKER[1]

Department of Entomology, University of Agricultural Sciences, G.K.V.K., Bangalore, India 560 065

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Polyacrylamide gel electrophoresis (PAGE) has been carried out on the defensive secretions of four species of *Pheropsophus* viz., *P. hilaris*, *P. occipitalis*, *P. bimaculatus* and *P. lissoderus*. From the defensive secretions, two protein fractions (A and B) in *P. hilaris*, six protein fractions (B, C, D, E, G and I) in *P. occipitalis*, four protein fractions (A, B, C and H) in *P. bimaculatus* and five protein fractions (C, F, G, I and J) in *P. lissoderus* have been isolated. Among these the fractions H, D, G, E, F and J are species-specific and the fractions B and C are common protein fractions in almost all species. The close relationship and occurrence of protein fractions among the species have been discussed.

(*Key words*: *Pheropsophus*, electrophoresis, defensive fluid)

INTRODUCTION

It is a well established concept that quinone compounds are the primary ingredients of the defensive secretions of most Coleoptera especially in the tribe Brachinini of Carabidae. Though numerous studies have been reported on the chemical constituents of the defensive secretions, the studies on the secondary compounds like proteins associated with the compounds of defensive fluid as a biogenetic parentage are very meagre. PASTEELS & DALOZE (1977) have identified some amino acid derivatives, lipids and saturated hydrocarbons as the ingredients of defensive secretion in chrysomelid beetles such as *Chrysolina* and *Doryphorina*. Similarly ALDRICH *et al.* (1978) have studied the tubular scent glands of *Oncopeltus fasciatus* and identified acetate as the major component of the defensive secretion. DATEO & ROTH (1967) reported gluconic acid and 2-hexenal in the defensive secretions of three species of *Eurycoris blattaria*.

The carabid *Pheropsophus* spp. are active predators and it has been recorded that they feed on some agricultural pest particularly *Oryctes rhinoceros*. More than six species have been recorded in India so far and it has a specific defensive mechanism as it jets out highly volatile and irritating substance when it has been disturbed. Apart from these, they morphologically differ as they have slight variations on their elytra and pronotum. These variations among them have brought attention to study those in reference to presence of protein in their defensive fluid and also based on the thorough survey of literature, it has been known that the studies on protein in their defensive fluid as biogenetic parantage are not studied in much detail.

Hence, the present investigation has been made to determine the species-specific protein, if any, in the defensive secretions of

1. Centre for Applied Genetics, Bangalore University, Bangalore, India 560056.

the four different species of *Pheropsophus* namely *P. hilaris, P. occipitalis, P. bimaculatus* and *P. lissoderus* to correlate with their similarity rather than the usual karyological studies.

MATERIALS AND METHODS

This investigation was carried out at the Department of Entomology, University of Agricultural Sciences (UAS), Gandhi Krishi Vignana Kendra (GKVK), Bangalore, India. Four species of *Pheropsophus* were collected from the UAS wetlands, Hebbal (890 MSL) and acclimatized to the laboratory conditions for a week. The defensive fluid of each species was obtained by pressing gently the abdominal region of the beetle with forceps and collected directly in Tris-HCl buffer (pH 7.5) for running electrophoresis.

Conventional polyacrylamide gel electrophoresis (PAGE) was carried out according to the methods developed by Davis (1964). The defensive fluid collected in Tris-HCl buffer 0.1 ml was applied to the gel tube using 0.5 per cent bromophenol blue as a marker. Electrophoresis was carried out in tris-glycine buffer (pH 8.3–8.9) at a constant current of 3 m A/gel tube. Gels were stained for protein in a solution of 1.0 per cent coomassie brilliant blue. A mixture of methanol, acetic acid and water in the ratio of 25:7:68 was used as a destainer. The intensity of different protein fractions were scanned with a 'Biochem' Densitometer (Model M 77) at 640 nm to the optical density (OD) values were plotted on a graph against the distance along the gel, mm by mm to convert the protein fractions (bands) into an electropherogram. In addition, the different fractions of proteins were analysed according to their Relative Mobility (RM) values.

RESULTS

Two protein fractions (A and B) in the defensive fluid of *P. hilaris*, four (A,B,C and H) in *P. bimaculatus* five (C,F,G,I and J) in *P. lissoderus* and six (B,C,D,E,G and I) in *P. occipitalis* have been identified. The protein fractions obtained in the defensive fluid of *Pheropsophus* spp. have been displayed as an electropherogram (Fig. 1). The RM values of each protein fraction of each species were coded and tabulated (Table 1). Among the fractions obtained in the protein profile of the defensive secretions of *Pheropsophus* spp., the fraction 'H' was found species-specific to

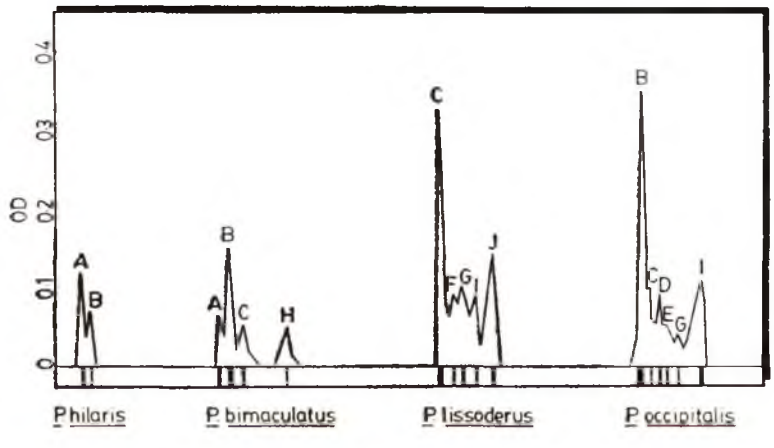

Fig. 1. Electropherogram showing the different protein fractions in the defensive secretion of four *Pheropsophus* species.

P. bimaculatus, 'D' and 'E' were specific to *P. occipitalis* and 'F' and 'J' for *P. lissoderus*. Of the only two protein fractions (A and B) existing in the defensive fluid of *P. hilaris*, fraction 'B' occurred commonly both in *P. occipitalis* and *P. bimaculatus*. Fraction 'C' was found in all the species except *P. hilaris*. Fraction 'G' and 'I' were present in the protein profile of both *P. occipitalis* and *P. lissoderus*.

DISCUSSION

Of the several approaches that have been taken up on biochemical systematics, electrophoresis is a simple and versatile tool to solve problems in systematics. Though the protein fractions in the defensive secretions of *Pheropsophus* spp. differed in numbers, the presence of species specific proteins such as 'H', 'D' and 'E' and 'F' and 'J' was observed in *P. bimaculatus*, *P. occipitalis* and *P. lissodorus* respectively. Some of the protein bands such as 'B' 'C', 'G' and 'I' seemed to be common to more than one species. ALDRICH *et al.* (1978) found a mixture of compounds including four types of protein in the defensive secretions of the coreid bug, *Leptoglossus phyllopus* and also reported that the protein fractions of the secretion catalyzes the production of the most irritating constituents of the defensive blend from a relatively non-toxic precursors within the impermeable cuticular reservoir of the gland.

Carbohydrate substances have also been reported in the defensive secretion of chrysomelid beetles (PASTEELS & DALOZE, 1977). ROTH & STAY (1958) reported that 2-ethyl 1-4-benzoquinones are the constituents of the defensive secretion of *Diploptera punctata* and *Diaperia maculata*. The principal component (92–98%), of the upper odoriferous phase of the defensive secretion of six species of *Polyzosteria* was identified as travs-hex-2-enol, hex-2-enol, hex-2-enoic acid and four related mionor components

TABLE 1. The relative mobility (RM) values of each Protein fraction of four different *Pheropsophus* species.

Sl. no.	Name of protein fraction	*P. hilaris* RM	*P. bimaculatus* RM	*P. occipitalis* RM	*P. lissoderus* RM
1.	A	0.01	0.01	—	—
2.	B	0.04	0.04	0.04	—
3.	C	—	0.09	0.09	0.09
4.	D	—	—	*0.10	—
5.	E	—	—	*0.14	—
6.	F	—	—	—	*0.15
7.	G	—	—	0.18	0.18
8.	H	—	*0.26	—	—
9.	I	—	—	0.28	0.28
10.	J	—	—	—	*0.31

* species - specific protein fractions.

were also presented (WALLBANK & WATERHOUSE, 1970).

According to SNYDER (1977) the presence and absence of protein bands may be caused by additions or deletions of segments of the polypeptide rather than the result of amino acid substitutions, which have little net effect on the weight of the molecule. Further, SYNDER (1977) stated that these quantitative changes in polypeptides lead to the regulatory changes in the organism associated with gene rearrangements. Further, SYNDER (1977) described the divergence of two genera of bees *Halictus* and *Lasioglossum* based on protein evolution and suggest that lineages of protein evolution goes at a constant rate.

PASTEELS *et al.* (1984) studied the close relationship between *Chrysomelina* and *Phratona* and *Leptinotarsa* and *Gonioctena* based on the divergence of chemicals present in their defensive secretions. WALLBANK & WATERHOUSE (1970) stated that the chemical composition of the defensive secretion confirms the existing classification systems in the *Blattodea* although there are some inconsistencies and further they suggested that the defensive scent may have some correlations with taxonomic relationships.

From this present study, it has been observed that the variations of protein fractions, the presence and absence of some common protein bands in their defensive secretions of *Pheropsophus* spp. According to Snyder (1977) it is possible to correlate the changes in protein fractions most probably due to quantitative changes in the peptides to bring forth the regulatory changes in the organism. Hence it is suggested that the protein variations in the defensive secretion of *Pheropsophus* spp. may have one of the factors to bring variations among them.

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TOXIC AND BEHAVIOURAL EFFECTS OF COMMONLY USED MOSQUITO LARVICIDES ON THE WATERHYACINTH WEEVILS, *NEOCHETINA EICHHORNIAE* AND *N. BRUCHI*

P. N. GANGA VISALAKSHY
Division of Entomology and Nematology, Indian Institute of Horticultural Research, Hessaraghatta Lake Post, Bangalore, India 560 089

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The contact and residual toxicity of commonly used mosquito larvicides to waterhyacinth weevils, *Neochetina eichhorniae* Warner and *N. bruchi* Hustache (Col. : Curculionidae) were determined under laboratory conditions. Among the tested larvicides, temephos and phenthoate were relatively safe to the insects. Fenitrothion was toxic on direct topical application, but innocuous to adults, when exposed to leaves after 0, 24 and 72 h of spraying of the larvicides. Chlorpyrifos and fenthion were highly toxic on topical application and also had prolonged residual toxicity on the insects. Dispersive behaviour caused by the above larvicides to *N. eichhorniae* and *N. bruchi* were also discussed.

(*Key words*: *Neochetina eichhorniae*, *N. bruchi*, mosquito larvicides, susceptibility, residual effect, dispersive behaviour)

INTRODUCTION

Waterhyacinth (*Eichhornia crassipes* (Mart., Solmns.) infested waterways are ideal environment for the breeding of disease vectors and mosquitoes (TOWNZEN & WILSON, 1983; GOPAL & SHARMA, 1981). It provides suitable habitats for msquitoes, protecting them from predators and reduces contact of eggs and larvae with larvicides (GUPTA, 1979). Moreover, certain species of mosquitoes like *Mansonia* sp. and *Coquillettidia* sp. prefer live waterhyacinth roots for pupation, to other hydrophytes (DEL FOSSE, 1977). Hence, control of waterhyacinth which would reduce mosquito multiplication by host-plant elimination and through increased activity of predatory fishes (DEL FOSSE, 1977), may have to be incorporated with any successful control programme.

Permanent suppression of waterhyacinth by releasing potential biocontrol agents like *N. eichhorniae* and *N. bruchi* has been achieved in many countries (HARLEY, 1990). A study was made under laboratory conditions to determine the susceptibility of these potential bioagents to commonly used mosquito larvicides, whereby biological control strategies could be formulated, for integrated control of mosquitoes.

MATERIALS AND METHODS

Adults of *N. eichhorniae* and *N. bruchi* collected from waterhyacinth plants grown in outdoor cement tanks (120 cm dia × 60 cm depth) where no insecticides or weedicides were sprayed, were used for the experiments. The larvicides tested with their field recommended dosages were chlorpyrifos - 1 ppm, fenthion - 1 ppm, fenitrothion - 2 ppm, phenthoate - 1 ppm and temephos - 1 ppm.

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Succeptibility of the weevils to mosquito larvicides:

The effect of the recommended dosage of the above larvicides on the weevils, by direct topical application as well as by exposure to leaves after 0, 24 and 72 h of spraying was determined.

For direct toxicity tests, adults were released into a clean dry Petriplate (10 cm diameter) and subjected to a uniform thin film of the respective larvicidal spraying, from an atomizer. The insects were transferred into clean dry plastic aerated jars (5×3 cm) with lid, where moist cotton was provided, as drinking water. Insects sprayed with tap water and provided with moist cotton was run parallel to other treatments, which served as control. Each treatment was replicated thrice, with ten adults per replication.

For determining the toxicity of the larvicides to the weevils by exposing the leaves after 0, 24 and 72 h of spraying, a healthy waterhyacinth plant was sprayed with the respective larvicide, covering both the surfaces of the leaves uniformly, which was kept in a plastic trough (5 litre capacity), filled with water. After allowing the excess larvicides to run off, a leaf was cut and exposed to adults, kept in an aerated plastic jar (10 × 15 cm), containing water. The jar was closed with a lid, to prevent the escape of the insects. The insects were taken back after 6 h of exposure and released into another aerated plastic jar, containing water and unsprayed whaterhyacinth leaves. Leaves from the plant were exposed to adult insects after 24 and 72 h of spraying to determine the residual toxicity.

Leaves of plant sprayed with tap water and exposed to adults after 0, 24 and 72 h of spraying was run parallel to other treatments which served as control. Each treatment was replicated thrice with 10 adults per replication. Observations were made till 72 h on the number of adults dead, which were later converted into percentages of adult mortality and subjected to Anova.

The experiment for *N. bruchi* and *N. eichhorniae* was done separately.

Effect of larvicides on the dispersal of insects:

Experiments were conducted under glass house conditions, to study whether the above larvicides affect the dispersive behaviour of *N. eichhorniae* and *N. bruchi*.

Fresh adults were released on healthy waterhyacinth plants, with no weevil damage. After 2–3 h the plant was sprayed uniformly with the respective larvicides and kept in a plastic rectangular trough, filled with water (50 litre capacity), amidst unsprayed plants. The sprayed and unsprayed plants were distanced 1 foot apart from each other by hanging weights. The plastic rectangular trough was covered with a transparent pinholed plastic sheet, to prevent the escape of the adults. Observations were made after 24 and 48 h on the number of adults both on sprayed and unsprayed plants. Each treatment was replicated thrice with 10 adults per replication.

RESULTS AND DISCUSSION

On topical application, temephos and phenthoate were found to be least toxic to both the species of adults (Table. 1). The other larvicides namely chlorpyrifos, fenthion and fenitrothion were found to be highly toxic causing 90, 83.84 and 51.12% mortality to *N. eichhorniae* and 90, 81.14 and 64.61% mortality to *N. bruchi* respectively.

Exposure of adults to leaves after 0, 24 and 72 h of spraying also revealed temephos and phenthoate to be least toxic to adults. (Table 1). Repeated application of temephos

was reported to cause no effect on the species density, diversity and richness of the salt marsh aquatic insect community (CAMPEL & DENNO, 1976). Fenitrothion though toxic on direct application was found to be totally innocuous to *N. eichhorniae* and *N. bruchi*, when exposed to leaves after 0, 24 and 72 h of spraying.

Studies on residual toxicity revealed chlorpyrifos and fenthion to be highly toxic after 24 h of spraying. After 72 h, fenthion was found non-toxic to *N. bruchi* and relatively safe to *N. eichhorniae* (Table 1). Similarly, chlorpyrifos was found to cause no mortality of *N. eichhorniae* but to cause 57.77% mortality of *N. bruchi* adults. Though *N. eichhorniae* and *N. bruchi* occupied the same habitat, they exhibited differential response towards chlorpyrifos and fenthion. Similar observations were reported earlier, about two larvivorus fishes *Aplocheilus linneatus* (Cur & Val.) and *Macropodus cupanus* (Cur & Val.) towards fenthion and temephos, which were attributed to diversified physiological processes, like mechanism of respiration (JACOB *et al.*, 1982). Immediate and long lasting effects of chlorpyrifos reported in the present study agree with the observation made by ALI & MULLA (1978), on aquatic non-target invertebrates.

Effect of larvicides on dispersal of insects:

Excepting fenitrothion, the rest of the larvicides were found to produce no negative effects on the migration of *N. eichhorniae* adults (Table 2). In *N. bruchi*, fenitrothion and phenthoate were found to inhibit the dispersal of insects from sprayed to unsprayed plants.

In addition to direct toxicity, the application of insecticides could alter the insect behaviour like foraging and dispersal of insects, whereby the effectiveness of the potential biocontrol agents could be modified or lessened, as reported by ELZENE et al. (1989). In the present study, taking into consideration the inhibition of dispersive behaviour by less toxic larvicides like

TABLE 1. Effect of mosquito larvicides on *N. eichhorniae* and *N. bruchi* adults.

Treatment and conc.	Adult mortality (%)							
	Direct spraying		Exposure of insects after					
			'0' h of spraying		24 h of spraying		72 h of spraying	
	N. eichhorniae	*N. bruchi*	*N. eichhorniae*	*N. bruchi*	*N. eichhorniae*	*N. bruchi*	*N. eichhorniae*	*N. bruchi*
Chlorpyrifos–1ppm	90.00	90.00	90.00	90.00	90.00	90.00	0.00	57.77
Fenthion – 1 ppm	83.86	81.14	74.98	68.83	50.83	41.14	24.14	0.00
Fenitrothion – 2 ppm	51.12	64.61	0.00	0.00	0.00	0.00	0.00	0.00
Phenthoate – 1 ppm	15.00	6.14	19.21	11.06	6.14	6.14	17.21	0.00
Temephos – 1 ppm	12.28	6.14	13.07	6.14	6.14	0.00	6.14	6.14
Control	6.14	14.99	6.14	18.43	6.14	0.00	6.14	0.00
CD at 5%	22.99	21.65	22.59	12.98	11.47	6.75	17.15	21.46

TABLE 2. Dispersion behaviour of *N. eichhorniae* and *N. bruchi* adults.

Treatment and conc.	% of adults in untreated plants after 48 h	
	N. eichhorniae	*N. bruchi*
Fenthion – 1 ppm	46.74	44.09
Phenthoate – 1 ppm	43.55	13.37
Chlorpyrifos – 1 ppm	46.91	35.88
Temephos – 1 ppm	46.34	46.42
Fenitrothion – 2 ppm	30.56	19.83
Control	44.33	53.98
CD at 5%	8.27	15.19

fenitrothion and phenthoate and the persistance of high toxicity of chlorpyrifos and fenthion, the adoption of spraying patterns like patch spraying could help to minimise the hazardous effects of the mosquito larvicides on the weevils, under field conditions.

The study thus proposes that larvicides like temephos, phenthoate followed by fenitrothion, which have high margins of safety can be utilized in integrated control programmes of mosquitoes without marked effects on *N. eichhorniae* and *N. bruchi*, while chlorpyrifos and fenthion can be harmful to these biocontrol agencies.

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FUNCTIONAL RESPONSES OF *EPIDINOCARSIS LOPEZI*, *HYPERASPIS DELIKATULA* AND *HYPERASPIS PUMILA* TO DIFFERENT DENSITIES OF *PHENACOCCUS MANIHOTI*

J. K. U. EMEHUTE & R. I. EGWUATU[1]

National Root Crops Research Institute, Umudike, P.M.B. 7006, Umuahia, Imo State, Nigeria.

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Three natural enemies, *Epidinocarsis lopezi* De Santis, *Hyperaspis delikatula* Mulsant and *H. pumila* Mulsant, of *Phenacoccus manihoti* Matile-Ferrero showed different types of functional response curves. *E. lopezi* showed a type III functional response curve while *H. delikatula* and *H. pumila* showed a type II functional response curve. Response to host or prey density was inversely density dependent when the number parasitised or killed was expressed as the percentage of the density of the host or prey supplied. Parasitisation rate of *E. lopezi* was higher at low *P. manihoti* densities. In choice experiments in which adults and ovisacs of *P. manihoti* were supplied to *H. delikatula* and *H. pumila*, the former fed on both adults and ovisacs whereas the latter fed only on the adults of *P. manihoti*. It is concluded that *E. lopezi* was a better biological control agent whose efficiency could be improved by releasing large numbers at low densities of *P. manihoti* early in the dry season.

(*Key words*: functional response, *Epidinocarsis lopezi*, *Hyperaspis delikatula*, *H. Pumla*, *Phenacoccus manihoti*)

INTRODUCTION

The cassava mealybug (CM), *Phenacoccus manihoti* Matile-Ferrero (Homoptera: Pseudococcidae), has continued to infest cassava in many parts of Africa for nearly two decades. The pest was first reported in Nigeria in 1979 (AKINLOSOTU & LEUSCHNER, 1981) and has continued to be very important in the southern parts of Nigeria in the dry season when late planted cassava showed severe signs of infestation. To control the pest, an exotic parasitoid, *Epidinocarsis lopezi* De Santis (Hymenoptera: Encyrtidae), was introduced to Nigeria (HERREN & LEMA, 1982). Despite the good spread and adaptability of *E. lopezi* in Nigeria (HERREN et al., 1987; AKINLOSOTU *et al.*, unpublished survey report) and the several indigenous coccinellid predators on CM (AKINLOSOTU & LEUSCHNER, 1981; UMEH, 1982) many cassava plots still show severe infestation in the dry season.

Recently functional response studies were carried out in the insectary to obtain information on the killing potential of *E. lopezi* and two frequently occurring local *Hyperaspis* species which predate on CM in Nigeria. The aim was to determine the desirability for further work with these species in the biological control of CM.

MATERIALS AND METHODS

This study was carried out in 1987 at the National Root Crops Research Institute (NRCRI), Umudike, Southeastern Nigeria, under insectary conditions. The temperature and the relative humidity (R H) in the insectary varied between 24.5 to 33.0°C and 65.5 to 95.0% respectively. Pairs of active

1. Present address : Anambra State University of Technology, P.M.B. 01660, Enugu, Nigeria.

male and female *E. lopezi* that emerged within 24th from parasitised (mummified) CM recovered from insectary culture were introduced into well ventilated cages. Each cage contained a potted, CM susceptible cassava plant, cultivar (CV) 60506, with known numbers of pre-ovipositing fourth instar nymphs earlier screened to ensure complete freedom from parasitisation before introducing a pair (male and female) of *E. lopezi* into each cage. Preovipositing fourth instar cohort were used because in a preliminary study we found that *E. lopezi* parasitised mostly fourth instar nymphs. The number of CM per cage (treatment) varied between 5, 10, 15, 20, 25 and 30 and was replicated five times. Mummified CM were recorded 16 days after the introduction of *E. lopezi*. A mean developmental time of 14.3 days at 27°C from egg to adult for *E. lopezi* had earlier been established (HERREN & LEMA, 1982).

The functional response studies with the two coccinellids, *H. delikatula* and H. *pumila*, were carried out by introducing a pair (male and female) of the adults into a Petri-dish containing pre-ovipositing CM individuals at densities of 5, 10, 15 and 20 replicated five times. The cover of Petri-dish was perforated and closed with fine cloth mesh for aeration. Counts of live CM were taken every 24 h for 7 days; killed and any ovipositing CM were replaced, after each observation, with any pre-ovipositing fourth instars from the insectary culture.

The rate of predation on the ovisacs and choice feeding in the presence of ovisacs and adults of CM were also investigated. Newly emerged adult predators 12 – 24 h old were used in both studies. For the rate of predation on the ovisacs, adult predators were caged in pairs (male and female) for 48h in Petri-dishes with 20 ovisacs. The ovisacs were obtained from 3 – 4 day old ovipositing CM to ensure adequate number of eggs since our preliminary studies showed that ovisacs laid by 3 – 4 day old ovipositing adults contained higher number of eggs than those laid before or after this period. There were ten replications per predator species. Similarly in the choice experiments, paired (male and female) adult predators were caged with 20 6–12h old pre-ovipositing adult CM and 20 ovisacs for 48h. These CM adults were used to ensure that no oviposition occurred before 48h. There were ten replications per pair of predator species.

To obtain functional response curves, the mean number of hosts parasitised or killed in the different treatments was plotted

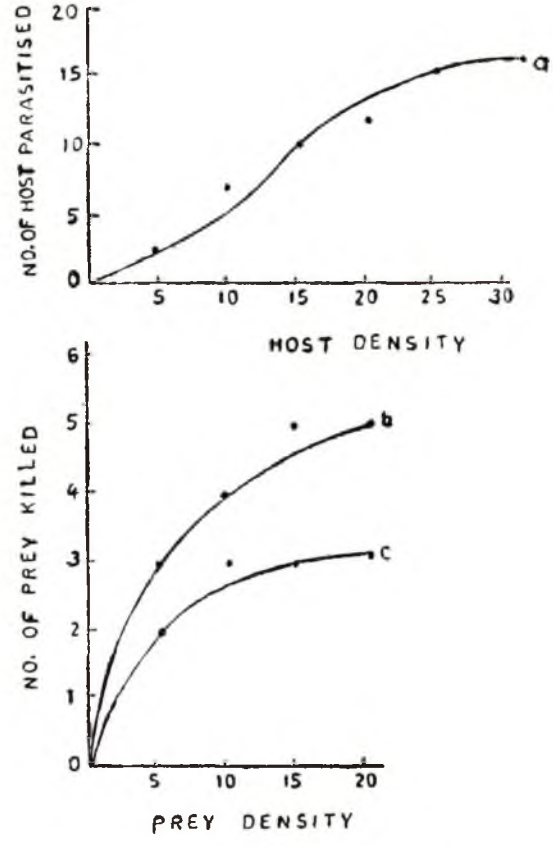

Fig. 1. Functional response curves of a. *E. lopesi*, b. *H. delikatula* and *c. H. pumila* on *P. manihoti*.

against the density levels of the host or prey. Also the proportion (%) of host parasitised or killed was plotted against host or prey density for a better understanding of the killing power of the entomophagous species as host or prey density increased.

RESULTS

The functional responses of *E. lopezi*, *H. delikatula* and *H. pumila* are shown in Figure 1, a, b and c, respectively. *E. lopezi* showed a type III functional response, while *H. delikatula* and *H. pumila* showed a type II functional response. Response was inversely density dependent when the number of hosts parasitised or the number of prey killed was expressed as a percentage of the numbers originally supplied to the entomophages (Fig. 2, a, b and c). The mean daily rate of prey consumption by the predatory species is shown in Table 1. *H. delikatula* fed on the adults and the ovisacs while *H. pumila* fed only on the adults of CM. However when starved for several days, *H. pumila* fed on the eggs of CM leaving the mealywax materials.

DISCUSSION

Functional response studies provide useful predictive indices in the choice of biological control agents since such studies provide

TABLE 1. Mean daily rate of consumption of adults and ovisacs of *P. manihoti* by *H. delikatula* and *H. pumila*.

Predator Species	Stage of *P. manihoti*		
	Adult	Ovisac	Adult + Ovisac
H. delikatula	3 – 5	4 – 5	2 + 2
H. pumila	2 – 3	0	2 + 0

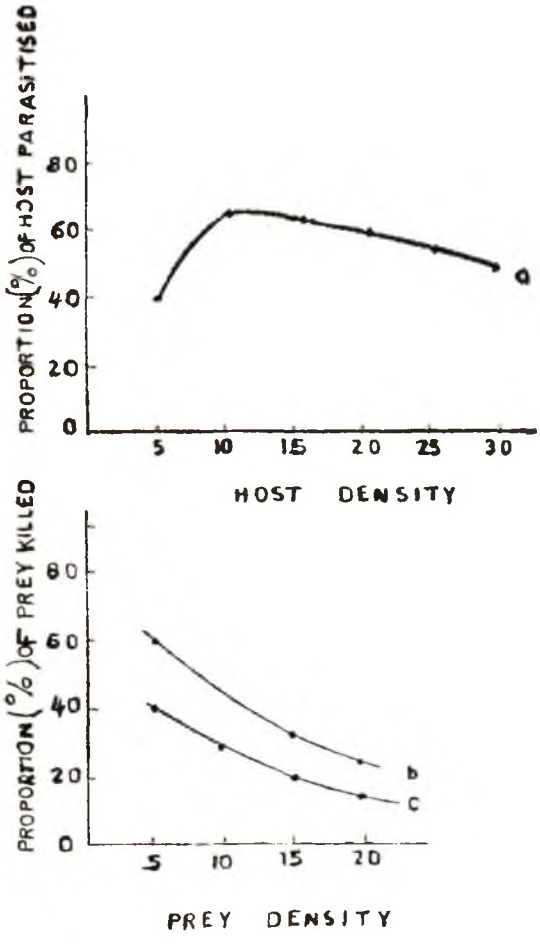

Fig. 2. Relationship between: host density and the % of host parasitised by *E. lopezi* (a), prey density and the % of prey killed by *H. delikatula* (b) and prey density and the % of prey killed by *H. pumila* (c).

information on the killing powers of the bio-agents at different host or prey densities. The two families of natural enemies studied showed different functional response curves indicating different regulating effects on CM. The adult coccinellids with type II functional response curve (HOLLING, 1965) potentially cannot regulate to stabilise the population of CM since the per cent mortality will constantly decline as the population of CM increases (PRICE, 1975). In Zaire coccinellids reduced drastically CM population only

after CM had severely damaged cassava plants (HENNESSEY & MUAKA, 1987). Based on our field observations the role of coccinellid predators in the control of CM in Southeastern Nigeria is similar to the situation in Zaire. The lag effect of indigenous coccinellids such as *Hyperaspis* species could be attributed to their long life cycle (LEMA & HERREN, 1982) and possible low rate of reproduction in comparison to CM. The observed drastic reduction of CM population when damage had been done may be due to several mortality facotrs. CM population could be reduced as a result of death from intraspecific competition for space and food with increase in CM population as infestation progressed towards the end of the dry season (self destruction). Also increases in the population of active predators (adults and larvae) as CM infestation progressed would increase the feeding pressure on CM and contribute to the belated reduction in CM population.

E. lopezi whose functional response curve was of HOLLDING's (1965) type III could regulate CM since in principle parasitisation rate would increase as pest density increased (PRICE, 1975). Under field conditions parasitisation rates increased with increase in CM density (EMEHUTE, 1987). In spite of the potential of *E. lopezi* and its ubiquity in Southeastern Nigeria, populations of CM have continued to be high resulting in severe damage to cassava plants. The cause of this despite its (*E. lopezi*) specificity to CM (NEUENSCHWANDER & MADOJEMU, 1986) and ability to cause higher per cent mortality with increase in host population, may be due to its low reproductive capacity and low degree of active parasitism (NEUENSCHWANDER & MADOJEMU, 1986) and the effects of native hyperparasitoids (EMEHUTE, 1987). If the number of *E. lopezi* is increased in the CM-infested cassava fields through field releases early in the dry season, more *E. lopezi* will be available to parasitise more CM, resulting in a better control of CM, before the adverse intervention of hyperparasitoids on *E. lopezi* population. This can be achieved through inundative field releases of *E. lopezi* at the beginning of the dry season following programmed pest surveys and pest counts.

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EPIZOOTICS OF *ERYNIA NEOAPHIDIS* (ZYGOMYCETES: ENTOMOPHTHORALES) IN FIELD POPULATION OF *BREVICORYNE BRASSICAE* (HOMOPTERA: APHIDIDAE) ON CABBAGE

C. GOPALAKRISHNAN & K. S. MOHAN

Division of Entomology and Nematology, Biological Control-Insect Pathology, Indian Institute of Horticultural Research, Hessaraghatta, Bangalore, India 560 089

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The natural incidence of the entomophthoraceous fungus *Erynia neoaphidis* Remaudiere & Hennebert (=*Entomophthora aphidis* Hoffman sensu Thaxter) has been reported from field populations of *Brevicoryne brassicae* L. on cabbage. The epizootiological studies showed that the level of infection reached a peak of 80.6 ± 18.2% on February 20, 1990. The total average percentage mortality recorded by the fungus during February-March, 1990 was 47.5±17.9 with a temperature range of 14.5 to 31.7° C and relative hunidity from 51.5 — 77.7%. The importance of irrigation in increasing intra-canopy humidity and thereby inducing repeated epizootics on aphids has also been discussed.

(*Key words: Erynia neoaphidis*, *Brevicoryne brassicae*, epizootics)

INTRODUCTION

The entomopathogenic fungus *Erynia neoaphidis* Remaudiere and Hennebert (=*Entomophthora aphidis* Hoffman Sensu Thaxter) is the most common of the Entomophthoraceae found on aphids and is widespread in Europe, Middle East, North America, Mexico and elsewhere (REMAUDIERE & HENNEBERT, 1980). The fungus is known to infect cereal aphids (BODE, 1984; PAPIEROK & HUVUKKALA, 1986; FREIER *et al.*, 1986), rose aphid (AGUDA-SILVA, 1984), pea aphid (HUTCHINSON & HOGG, 1985) and lupin aphids (GRUPPE & ROCOUBER, 1988). Recently, this fungus has been found to attack the cabbage aphid, *Brevicornye brassicae* L. on cabbage in an epizootic form in our Research Station. The fungus *E. neoaphidis* acts as a major biotic mortality factor in keeping the pest under economic threshold level. This paper reports the observations made during the epizootic occurrence of *E. neoaphidis* on *B. brassicae* on cabbage at Indian Institute of Horticultural Research Farm, Hessaraghatta, Bangalore.

Contribution No. 73/91

MATERIALS AND METHODS

The Cabbage variety 'Meenakshi' F_1 Hybrid was raised in three 20 m^2 plots at this research station in order to make observations on the occurrence of insect pests and the disease. The crop was raised during the month of November, 1989, and it remained in the field till March 13, 1990.

Observations were made at an interval of seven days in all the three plots for the fungus *E. neoaphidis*, as it was the main biotic mortality factor, from Feb. 13 to Mar. 13, 1990. Observations were made on the percentage mortality of the aphid due to fungus in ten unit area of one cm^2 per leaf per plant of ten such leaves per plot at random. The average percentage mortality from each leaf was

taken and the total average percentage mortality was calculated by pooling the data so obtained from all the ten leaves from each of the three plots. About ten leaf samples infested with aphids from each plot collected at random from the field in the month of February were kept in the laboratory in plastic containers on moist surface and observations made on the fungal infection. Simultaneously, the meteorological data were collected regularly during the crop period from the I.I.H.R. weather observatory.

RESULTS AND DISCUSSION

The fungus identified as *E. neoaphidis* (IMI. No. 337961), infects all the four nymphal stages and the alate forms of *B. brassicae*. The alate forms were found to be highly susceptible to this fungus. The infected aphids were dark reddish brown in colour and found firmly attached to the surface of the foliage by means of hyphal rhizoids (Fig. 1 a–c). Conidia more or less globose to ovoid, papillate, measuring 17.5 – 20 μm × 15.5 – 17.0 μm (Fig. 1, d, e). Eventhough *Entomophthora aphidis* Hoffman has been reported from New Zealand on cabbage aphid (LOWE, 1963) and from India on spotted alfalfa aphid (MATHUR & SRIVASTAVA, 1966) and *E. neoaphidis* on cereals (BODE, 1984; PAPIEROK & HAVUKKALA, 1986; FREIER *et al.*, 1986), rose aphid (AGUDA-SILVA, 1984) pea aphid (HUTCHINSON & HOGG, 1985) and lupin aphids (GRUPPE & ROCOUBER, 1988) from elsewhere, this appears to be the first record of this fungus on *B. brassicae* L. (IIE No. A. 20945) on cabbage from India.

The population of *B. brassicae* was very high in all the three plots (26.2 nymphs per cm^2 leaf area). The fungal epizootic was noticed during the month of Feb. and Mar. 1990. The average percentage mortality due to fungal infection during Feb. was 53.6 and that of Mar. was 37.7 (Table 1). Thus, the total average percentage mortality recorded during February and March by fungus was 47.5 ± 17.9. The aphids collected from the field and kept in the laboratory showed 31.0% mortality due to fungus.

The sudden outbreak of the fungus was noticed on Feb. 13, when the percentage mortality recorded was 40.1 ± 13.1, which rapidly increased to a peak of 80.6 ± 18.2 on Feb. 20. Gradual decline in the percentage mortality of 40.2 ± 22.6 and 43.2 ± 20.9 was observed on Feb. 27 and Mar. 6 respectively, and at the end of cropping season the percentage mortality dropped rapidly to 32.2 ± 14.7 (Table 1).

The high level of infection of 80.6 ± 18.2 on Feb. 20 may be attributed to the high conidial density in the air coincided with the high density of the nymphal population on the crop as observed by COREMANS – PELSENEER *et al.* (1983). The fungal epizootic noted on Feb. 13, remained till March, 13, over the crop. Studies made by MILLSTEIN (1982) on microclimate humidity influence on conidial discharge in *Erynia* sp. on alfalfa weevil showed that infected weevil larvae in the alfalfa canopy showered conidia when intra-canopy humidities exceeded 91% RH, suggesting an empirical humidity threshold for conidial discharge in the 91 to 92% RH range. Thus, the intra-canopy humidities

TABLE 1. Natural incidence of *Erynia neoaphidis* on *Brevicoryne brasiscae* on cabbage.

Period of observation	% mortality $\bar{x}$ ± SD
13–2–90	40.1 ± 13.1
20–2–90	80.6 ± 18.2
27–2–90	40.2 ± 22.6
6–3–90	43.2 ± 20.9
13–3–90	33.2 ± 14.7

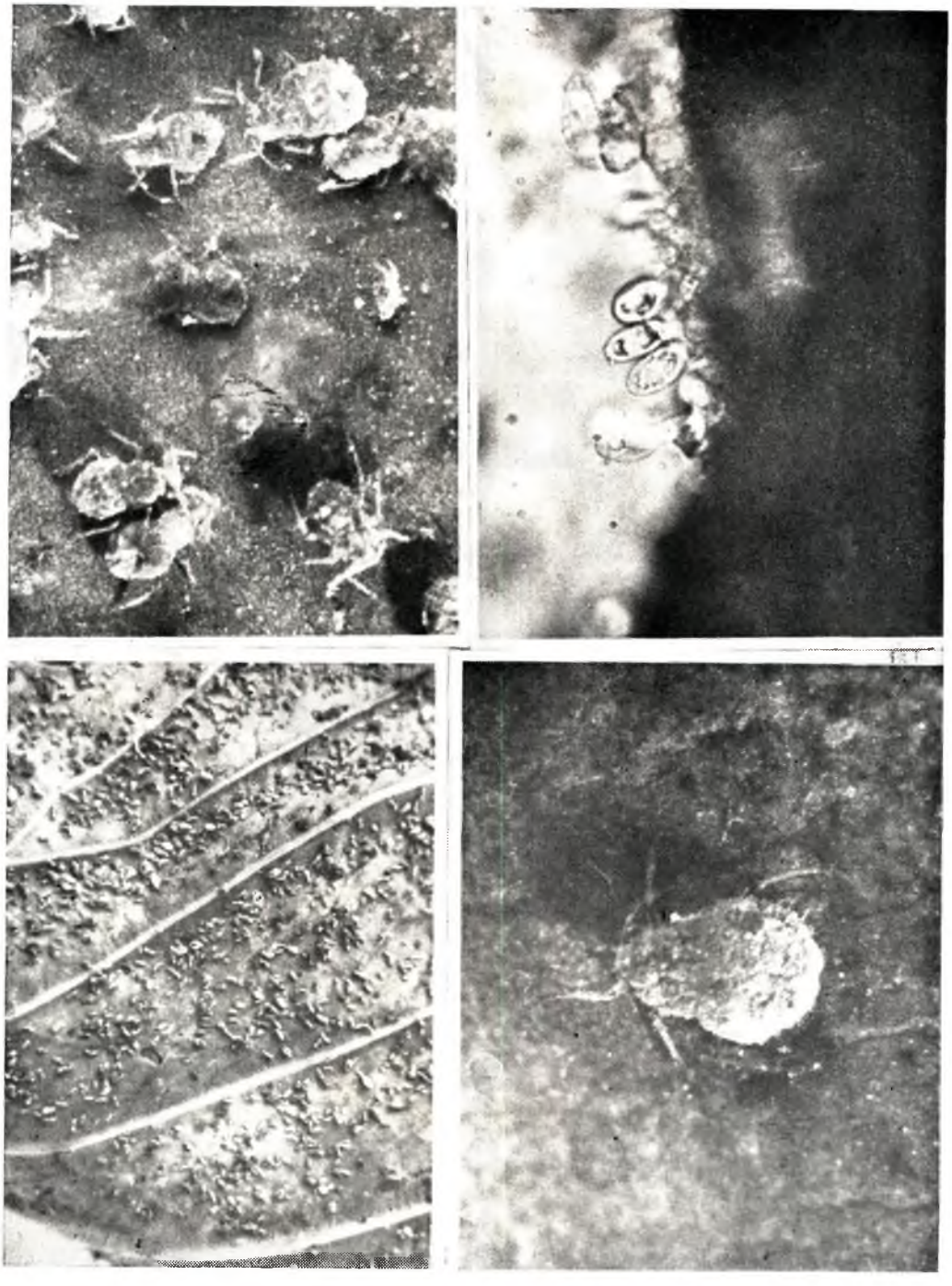

Fig. 1. *E. neoaphidis* infecting nymphs of *B. brassicae*.

a) A portion of cabbage leaf showing large number of *E. neoaphidis* infected nymphs.
b) Different stages of nymphs affected by the fungus, × 30.
c) A single fungal infected aphid showing growth on entire body and appendages, × 70.
d) Conidial stage of *E. neoaphidis* on the body surface, × 400.

e) Conidial stage of *E. neophidis* on appendages, × 200.

existed in cabbage might have also played similar role in the discharge of conidia in the case of *E. neoaphidis* and thereby maintained continuous infection of aphids on cabbage. It is further evident from the meteorological data that the average minimum and maximum temperature recorded during epizootic period Feb. 13 to Mar. 13, was 14.5 – 19.1°C and 28.5 – 31.7°C, respectively, and the average relative humidity recorded during the period for morning and evening hours was 64.5 – 77.7% and 51.5 – 64.4%, respectively (Table 2). Thus, the temperature range 28.5 – 31.7°C seemed to have helped in increasing the intra-canopy humidity and supported the epizootics. However, the influence of temperature in inducing fungal infection needs further study.

There was absolutely no rainfall throughout the cropping season. The weekly irrigation and the available microclimate inside the plant canopy probably triggered the fungal epizootics repeatedly on aphid population. In the case of cabbage variety 'Meenakshi' F_1 hybrid, the leaves are large, broad and thick which might have supported enough moisture thereby increasing the intra-canopy humidity after irrigation which itself is enough to support fungal epizootic on aphid pest. The experiments carried out on the efficacy of *E. neoaphidis* under field condition with or without irrigation of the crop against *Aphis fabae* on field beans by WILDING *et al.* (1986), showed that when there was little rain, irrigation greatly increased the proportion of aphids killed by *E. neoaphidis*, confirming our above observation.

Whatever may be the reasons for the epizootics of *E. neoaphidis* in *B. brassicae*, the fungus remains a major biotic mortality factor on *B. brassicae* populations on cabbage, where the microclimate itself will provide required humidity for the fungus to cause infection.

TABLE 2. Weekly meteorological data (1990) recorded at I.I.H.R. observatory.

Month	Temp. (°C)		Relative humidity		Rainfall (mm)
	Mean min.	Mean max.	Morning	Evening	
February					
1—7	10.8	28.8	75.0	69.7	—
8–14	14.5	28.5	77.7	62.0	—
15–21	15.2	31.0	75.5	51.5	—
22–28	14.8	30.4	75.4	61.2	—
March					
1–7	19.0	31.7	64.5	53.6	—
8–14	19.1	29.5	70.4	64.4	—
15–21	17.7	31.2	76.0	44.0	—

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LOCALIZATION OF NUCLEOLUS ORGANIZER REGIONS IN THE CHROMOSOMES OF AN APHID *MACROSIPHONIELLA SANBORNI* (HOMOPTERA: APHIDIDAE)

A. R. KHUDA-BUKHSH & I. KAR*
Department of Zoology, University of Kalyani, Kalyani, W.B., India 741 235

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Aphid chromosomes do not reveal any longitudinal differentiation in form of primary/secondary constrictions on the metaphase chromosomes by ordinary Giemsa staining. However, nucleous organizer regions (NORs), which are closely associated with secondary constriction (SC) sites, were localised in the metaphase chromosomes of an aphid, *Macrosiphoniella sanborni* by deploying the one-step silver staining method. NORs were localized at one terminal end of each homologue of pair no. 2 as a round, discrete Ag-positive body at metaphase. In interphase, mostly one, and occasionally two, silver-positive masses could be observed which continued to appear till early prophase. The NORs were very similar in pattern to that of *Lipaphis erysimi* the only other species of aphid studied for NORs so far.

(*Key words*: nucleolus organizar region, aphid, *Macrosiphoniella*, secondary construction site, pest)

INTRODUCTION

Aphid chromosomes apparently lack any primary/secondary constriction(s) as revealed from ordinary Giemsa staining (BLACKMAN, 1980; KHUDA-BUKHSH & PAL, 1985; KHUDA-BUKHSH & KAR, 1990) and are claimed to be holokinetic in nature (WHITE, 1973; KHUDA-BUKHSH & DATTA, 1981). Generally, the size of SCs (secondary constrictions), the size of Ag-NORs and the rDNA contents, are closely correlated with one another (WARBURTON & HENDERSON, 1979; TAKAI & OJIMA, 1986). The secondary constrictions of metaphase chromosomes, known as nucleolus organizer regions (NORs) because of their association with nucleoli, are believed to be chromosomal sites of genes coding for 18s + 28s rRNA in human and several mammalian species (HENDERSON *et al.*, 1972, 1974 a, b; PARDUE & HSU, 1975). Several N-banding techniques have been used to reveal NORs in chromosomes of a wide group of vertebrates (DENTON *et al.*, 1976; GOODPASTURE & BLOOM, 1975; HOWELL & BLACK, 1980; KLIGERMAN & BLOOM, 1977; TAKAI & OJIMA, 1986; GOLD, 1984; MAYR *et al.*, 1986 and many others), and in some insects with localized (monokinetic) centromeres (RUTHMAN & PERMANTIER, 1973; FUNAKI et al., 1975), but very limited works have been carried out in insects with diffused centromeric activity. So far, N-banding has been studied in only one species of hemipteran, *Coreus marginatus* (NOKKALA & NOKKALA, 1984) and on one species of aphid, *Lipaphis erysimi* (KAR & KHUDA-BUKHSH, 1991), for which the present study was undertaken primarily with a view to extending the knowledge on NORs in aphids and to detect the SC sites in chromosomes of *Macrosiphoniella sanborni* a pest infesting a multitude of host plants.

* Present Address : Malaria Research Centre, 1752, 13th Main Road, Anna Nagar West, Madras 600040, India.

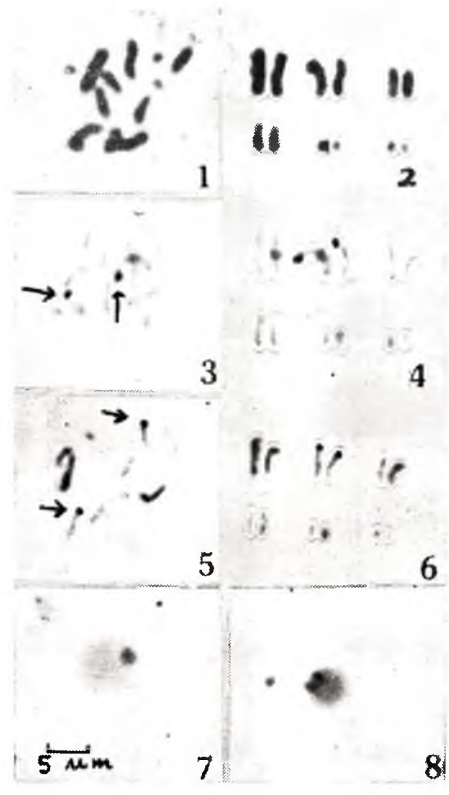
MATERIALS & METHODS

The chromosome preparations were made from tiny embryos of apterous viviparous females of *Macrosiphoniella sanborni* collected from Chrysanthemum plants at Simla, Himachal Pradesh, by following the technique described earlier (KHUDA-BUKHSH & PAL, 1985) and air-dried slides were subjected to both Giemsa and Silver-nitrate staining (HOWELL & BLACK, 1980).

RESULTS AND DISCUSSION

The Giemsa-stained metaphase complements (Fig. 1) and the karyotype (Fig. 2) revealed 2n = 12 chromosomes. The chromosomes did not show any longitudinal differentiation in form of primary and/or secondary constrictions in the Giemsa-stained preparations. However, in the silver-nitrate stained preparations (Figs. 3–6), there was a round discrete silver-positive body appearing at one terminal end of each homologue of pair no. 2. In most of the metaphase plates, these round NORs could be easily followed. In the interphase, mostly one (Fig. 7) and occasionally two (Fig. 8) silver-positive masses, presumably nucleoli, were observed, the occurrence of which could also be followed in early prophase plates.

The localization of NORs in *M. sanborni* is strikingly similar to that of the only other species, *Lipaphis erysimi*, studied so far (KAR & KHUDA-BUKHSH, 1991). In both the species, the discrete round silver-positive dots were observed at one terminal end of each homologue of pair no. 2 although the two species had different diploid numbers, 2n = 8 in *L. erysimi* and 2n = 12 in *M. sanborni*. This pattern of NOR-localization is also encountered in some insects and vertebrate species with monokinetic chromosomes. Though C-banding could not be successfully induced in *M. sanborni* despite some effort, the metaphase chromosomes of some other related aphids have been demonstrated to have terminal blocks of heterochromatin usually, and occasionally having interstitial blocks (BLACKMAN, 1976; 1980; KHUDA-BUKHSH & KAR, 1989). Therefore, most likely the NORs are included within the C-heterochromatin zones of aphid chromosomes, a fact which needs further verification by extension of data in related species. In the only hemipteran species, *C. marginatus*, NOKKALA & NOKKALA (1984)



Figs. 1–2. Photomicrographs of Giemsa-stained preparations: a metaphase complement showing 12 chromosomes (Fig. 1) and the karyotype (Fig. 2) prepared from Fig. 1.

Figs. 3–8. Photomicrographs of silver-stained preparations: Two metaphase complements (Figs. 3 and 5) showing Ag-positive regions arrowed) and the karyotypes (Figs. 4 and 6) prepared from Figs (3 and 5, respectively; Interphase showing one (Fig. 7) and two (Fig. 8) Ag-positive masses.

demonstrated N–banding which represented lateral differentiation along the axial core and showed similar behaviour as kinetochore structure in the holokinetic chromosomes. However, the techniques used to study N–banding in *C. marginatus* and NORs in *M. sanborni* were different. Further studies are warranted to critically analyze and understand the structural organization of chromosomes in these two groups of organisms believed to have holokinetic nature of chromosomes in common between them, but showing apparent difference in their N–banding patterns.

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EFFICACY OF ALTOSID^R, A JUVENILE HORMONE ANALOGUE AGAINST THE IMMATURES OF MANSONIOIDES MOSQUITOES, THE VECTORS OF *BRUGIA MALAYI*

K. KRISHNAMOORTHY, G. RAJENDRAN, S. SEBESAN & K. N. PANICKER
Vector Control Reserch Centre, Indiranagar, Pondicherry, India 605 006

(*Received* 5 *May* 1991)

Altosid (Methoprene), a juvenile hormone analogue was evaluated against immature *Mansonioides* mosquitoes, the vectors of Malayan filaraisis in coconut husk retting ponds which are the preferred breeding habitats. A decrease in larval density was observed at all the three dosages of 0.5, 1.0 and 2.0 ppm. The percentage reduction (%R) in larval density when compared to the natural increase/ decrease showed a higest reduction of 69.36% in ponds treated at 2.0 ppm. Adult emergence was inhibited by 14 days, 21 days and 28 days at 0.5, 1.0 and 2.0 ppm respectively. Laboratory observations also showed that none of the larvae treated at 2.00 ppm emerged into adults, and, only 1.45 % and 1.52 % of the larvae treated at 0.5 and 1.0 ppm respectively completed emegence successfully. A sudden decrease in larval densiy in the treated ponds and high mortality of treated larvae suggested the larvicidal effect of this compound.

(*Key words*: Altosid, insect growth regulator, *Mansonioides* control)

INTRODUCTION

Use of chemical insecticides has long been discouraged due to the development of resistance in insect vectors. Hence, alternate agents are being explored extensively. One such alternative which has received adequate attention in recent years is Insect Growth Regulators (IGRs). While the efficiency of this agent against other mosquito larvae had been studied widely (PHANTAUMACHINDA & WATTANACHAI, 1978; MULLA & DARWAZHE, 1975; SELF *et al.*, 1978; NELSON *et al.*, 1976) little work has been carried out against *Mansonioides* larvae. Therefore, a study was conducted to evaluate the effect of Altosid^R, a synthetic juvenile hormone analogue against mosquitoes belonging to the subgenus *Mansoniodes* Theobald 1907 of genus *Mansonia*, the vectors of Malayan filariasis, in Shertallai, Kerala, and the results are presented here.

MATERIAL AND METHODS

Field trials were conducted in Mararikulam, a village in Shertallai taluk which is highly endemic (21.3%) for Malayan filariasis. Twelve polluted natural ponds, used for retting coconut husks were selected to conduct this study. The surface area of these ponds ranged from 50 to 100 m^2 with depth between 3.0 – 4.0 m. Water temperature ranged between 20°C and 32°C, the pH 6.5 and 8.0 and salinity 162 and 754 ppm. All these ponds were heavily infested with aquatic weeds such as *Pistia stratiota*, *Salvinia molesta* and *Eichhornia crassipes* to the roots of which the immatures of *Mansonioides* larvae get attached for respiration and survival. Altosid^R (SR_5) (Methoprene – Isopropyl (E, E) – 11 – Methoxy – 3, 7, 11 – trimethyl - 2,4-dodecadienoate), with an active ingredient of 5% was sprayed using Ganesh hand sprayer in the small hours of the morning. Three

different concentrations viz. 0.5 ppm, 1.0 ppm and 2.00 ppm were employed in ponds with three replicates for each concentration. Three ponds were left unsprayed and maintained as controls.

Larval density was measured by using a specially designed cloth dipper which consisted of a metal ring with a diameter of 40 cm attached to a 2 m long wooden handle. The metal ring was provided with a 1 m long cloth (muslin) bag. Dips were taken by lowering the dipper in its inclined position well below the levels of roots of floating weeds and raised slowly so as to collect the plants without much disturbance. The plants were transferred to enamel trays, with small quantity of water and the roots of the plants were shaken to dislodge the larvae and pupae. The detached larvae and pupae were counted. Three dips, one form the centre of the pond and two from the periphery were taken from each pond. The larval density was expressed as number per dip. Samples were taken in all the ponds, 24 h and 48 h prior to and after the treatment. Thereafter, it was repeated at weekly intervals for a period of one month. Samples were released back in to the respective pond after counting. Percentage reduction (%R) in larval density was calculated following the method of MULLA *et al.* (1971).

$$\%R = 100 - [(C1/T1)*(T2/C2)*100]$$

where C1 = average number of larvae, pretreatment in control ponds; T1 = average number of larvae, pretreatment in treated ponds.; C2 = average number of larvae, post treatment in control ponds; and T2 = average number of larvae, posttreatment in treated ponds.

Larvae along with water samples were collected from treated and untreated ponds after 24 hours, 48 hours, 7 days, 14 days, 21 days and 28 days of treatment. Observations were continued for completion of emergence of these larvae under laboratory conditions.

Emerging adult mosquitoes from the treated ponds, (one pond from triplicate treated ponds at each concentration) and one of the three untreated ponds were collected every day by using an emergence trap ($2 \times 2 \times 2$ m). These traps were tied permanently in a particular site. Though this was expected to prevent the oviposition by gravid females, the immatures which were already exposed to Altosid were not disturbed. Further, the immature duration is about a month and the observations on adult emergence was continued for 31 days. As IGR compounds are known to produce morphological abnormalities, thorough examination of the emerged adults from the treated ponds for their morphological characters was made.

Laboratory observations on the effect of Altosid against immatures of *Mansonioides* were also made. Three concentrations of Altosid (0.5, 1.0 and 2.0 ppm) were prepared in one liter of water in transparent plastic containers with a capacity of 2 liters. To each container 25 fourth instar larvae of *Mansonia annulifera* with a healthy pistia plant were added. Three replicates for each concentration and control were maintained. Daily observations on the mortality of different developmental stages such as larvae and pupae and the number of larvae pupated were made. Dead larvae with attached larval skin were counted separately and entered under larval mortality on pupation. Corrected mortality was calculated using Abbott's formula (BUSVINE, 1971). Student's T - test was used to find whether there was any significant difference in larval density between different samples.

RESULTS AND DISCUSSION

Among the three *Mansonioides* mosquitoes that are prevalent in this area, *M. annulifera* is the predominant species followed by *M. uniformis* nad *M. indiana*. Out of 321 *Mansonioides* collected from the emergence traps prior to treatment only 2 were identified as *M. uniformis* and the rest were *M. annulifera*.

The larval density prior to treatment ranged between 40.83 to 79.17 per dip in different ponds. A marked reduction in larval density was observed in ponds treated with 2.00 ppm Altosid after 24 hours. In the ponds treated with 1.00 ppm and 0.5 ppm the larval density showed a reduction only after 48 hours (Fig. la). However, these reductions from pretreatment level were not significant ($P>0.05$) in all the treated ponds. Large scale field trials with 1.0 ppm Altosid against *Culex pipiens fatigans* have also shown that there was no significant reduction in density of any stage of immatures as long as four weeks (NELSON *et al.*, 1976). *Mansonioides* larval density fluctuated widely without any trend and the breeding was not brought down to zero in any of the treated ponds throughout the observation period in contrast to the breeding of *A. aegypti* which was reported to be brought down to zero (PHANTAUMACHINDA & WATTANACHAI, 1978; AMINAH *et al.*, 1981; TEN HOUTEN *et al*, 1980). A sudden reduction in larval density in relation to concentration suggests the larvicidal effect of this compound. However, it has been reported that larvicidal effect of this compound against *Culex pipiens* was insignificant. In the untreated ponds the larval density showed an increasing trend upto one week after which it started declining but was not statistically significant ($P>0.05$) from the pretreatment level. The percentage reduction in larval density in treated ponds when compared to the natural change in untreated ponds showed that there was reduction from the pre-treatment level upto 14 days in ponds treated at 2.0 ppm, ranging between 26.71 and 69.36% at 48 and 24 h after

TABLE 1. Percentage reduction (%R) in larval density in treated ponds in comparison with untreated ponds.

Days after treatment	Ponds treated at		
	0.5 ppm (n = 122.5)	1.0 ppm (n = 221)	2.0 ppm (n = 127)
1	—13.92	24.41	69.36
2	52.84	57.52	26.71
7	20.75	—20.80	6.50
14	5.83	22.47	45.23
21	—253.01	—83.87	—17.83
28	1.75	73.74	—63.31

—: Denotes no reduction but increase in larval density.

n = Average pretreatment larval density.

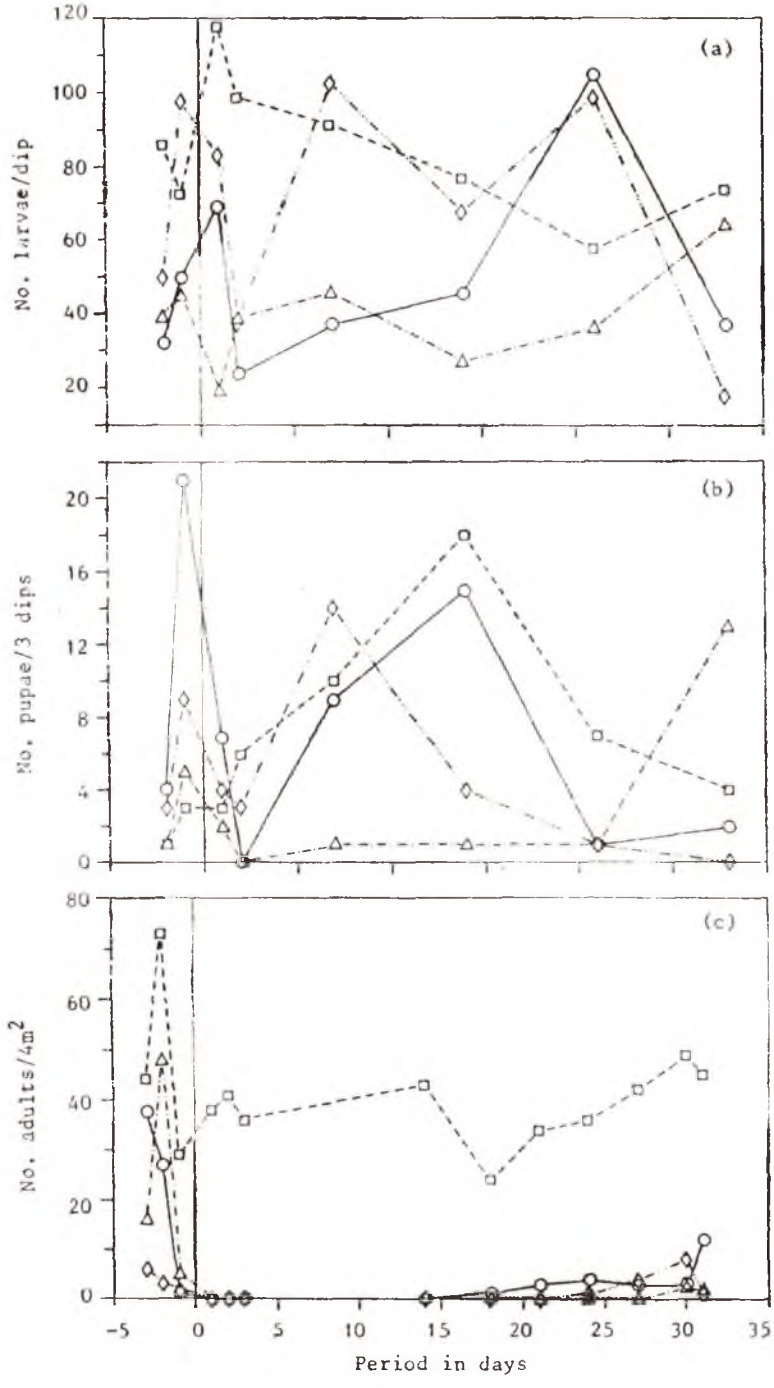

Fig. 1. Pre-and post-control density of Mansonioides larvae (a), pupae (b) and adults (c) in treated ponds with 0.5 ppm (○), 1.0 ppm (◊) and 2.0 ppm (△) Altosid and untreated ponds (□).

treatment respectively. In ponds treated at 0.5 ppm the reduction in larval density was observed only after 24 h and was maintained upto 21 days, whereas in ponds treated at 1.0 ppm post treatment observation showed a reduction for the first two days following which it fluctuated widely (Table 1). Pupae were also recorded in all the treated ponds throughout the period of observation (Fig. 1b) though they were in small number ranging from 1 to 21 per 3 dips.

Daily emergence of *Mansonioides* from 4 m^2 area ranged from 1 and 73 in different ponds prior to treatment. There was no adult emergence in the treated ponds from 24 hours after treatment upto 18th day in ponds treated at 0.05 ppm and upto 21st day in ponds treated at 1.0 ppm. Ponds treated with 2 ppm was found free from adult emergence upto 27 days (Fig. 1c).

Observations on adult emergence from larval samples (25 fourth instar larvae from each pond) collected at different intervals from treated and untreated ponds showed that there was total inhibition of adult emergence upto 21st day in ponds treated at 2.00 ppm and 15% of the larvae collected on 28th day after treatment successfully emerged into adults. None of the adults emerged from treated ponds showed any morphological abnormalities. At 0.5 ppm and 1.00 ppm total emergence inhibition was observed after 48 hours and continued upto 21st day after treatment. The duration of inhibiting adult emergence at 1.0 ppm observed during the present study was slightly shorter than that observed with Altosid 10 F compound against *Culex pipiens fatigans* (NELSON *et al.*, 1976). The percentage of larvae collected from untreated ponds that completed emergence ranged from 56 to 72%.

Daily observations on the mortality of fourth instar larvae after treatment at different dosages of Altosid under laboratory conditions are given in Table 2. At the end of four days the corrected mortality of larvae subjected to treatment at 0.5,

TABLE 2. Laboratory observations on percentage mortality and emergence of treated and untreated fourth instar larvae.

Concentration	%* mortality upto 4 days				%* mortality upto 8 days				%* emergence
	IV instar	IV instar while pupation	Pupae	Total	IV instar	IV instar while pupation	Pupae	Total	
0.5 ppm	13.33 (10.96)	14.67 (13.52)	17.33 (6.06)	45.33 (34.92)	36.23	31.88	30.43	98.55	1.45
1.00 ppm	18.67 (16.44)	22.67 (21.16)	18.67 (7.58)	60.00 (52.38)	33.33	36.36	28.79	98.48	1.52
2.00 ppm	17.33 (15.06)	29.33 (28.38)	24.00 (13.64)	70.67 (65.08)	29.41	39.71	30.88	100.00	0.00
Control	2.67	1.33	12.00	16.00	9.72	2.78	48.61	61.11	38.89

Figure in parenthesis denotes corrected mortality.

* : % out of 75 larvae in each category.

TABLE 3. Percentage of treated and untreated fourth instar larvae pupated on different days after treatment under laboratory conditions.

Days after treatment	Untreated (n=66)	Treated at		
		0.5 ppm (n=24)	1.0 ppm (n=23)	2.0 ppm (n=23)
1	13.64	12.50	8.70	21.74
2	24.24	20.83	26.09	30.43
3	22.73	16.67	30.43	26.09
4	13.64	8.33	8.70	4.35
5	6.06	4.17	4.35	4.35
6	6.06	16.67	4.35	4.35
8	13.64	12.50	17.39	8.70
10	0.00	8.33	0.00	0.00

Percentage out of 'n' in each category.

1.0, and 2.0 ppm was 34.92, 52.3 and 65.08% respectively. After 8 days of treatment all the larvae treated at 2.0 ppm failed to emerge whereas 1.45% and 1.52% of the larvae treated at 0.5 ppm and 1.0 ppm successfully emerged into adults. However, the mortality of untreated larvae exceeded 20% when the observation was prolonged upto 8 days. Mortality of treated fourth instar larvae on pupation with partly detached larval skin was recorded to be relatively higher at 1.0 ppm and 2.0 ppm, revealing the interfering effect of Altosid on the development/moulting of immatures. Mortality of considerable number of treated fourth instar larvae within four days of treatment confirms the larvicidal effect of this compound. High mortality in larval and pupal stages recorded in the present study is comparable with the report on a compound (VCRC/INS/A–23) with juvenile hormone activity against *C. quinquefasciatus* (TYAGI *et al.*, 1985).

Observations on the percentage of pupation in treated and untreated larvae at different time intervals did not show any marked difference (Table 3). This suggests that there was no appreciable delay in pupation due to Altosid treatment.

Thus it is evident from the present trial that when Altosid is used at 2.0 ppm concentration, adult emergence of *Mansonioides* can be inhibited by a minimum of 28 days from polluted pond habitats.

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PERFORMANCE OF SOME BIVOLTINE GENOTYPES OF *BOMBYX MORI* L. IN KASHMIR

G. N. MALIK, F. A. KUKILOO, A. S. SHAHEEN & A. R. TRAG
Division of Sericulture, Mirgund S K University of Agricultural Science & Technology,
Post Bag No. 23, GPO Srinagar, India 190 001

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Performance of sixteen bivoltine genotypes of *Bombyx mori* L. reared in spring seasons of 1986, 1987 and 1988 was evaluated. The pooled analysed data indicated that 'B 38 P', 'Saniish P', 'C 122', 'J 122' and 'Jam 21' were potential genotypes.

(*Key words*: *Bombyx mori*, bivoltine, genotype, spring, quantitative, traits)

INTRODUCTION

Deterioration in silkworm breeds is one of the reasons for decline in cocoon and raw silk production in Jammu and Kashmir. To overcome this short fall, high yielding silkworm strains have been evolved in the Division of Sericulture, Mirgund (DAS *et al.*, 1987, TRAG *et al.*, 1990) which are presently under field trial. Since their formal release and distribution of seed among rearers on large scale will take some time, simultaneous efforts were made to improve the existing genotypes. Their comparative performance was assessed to identify potential strains for commercial exploitation.

MATERIALS AND METHODS

Sixteen promising bivoltine silkworm genotypes (Table 1) out of 120 maintained at the Division of Sericulture, exhibited superiority for quantitative characters like fecundity, weight of mature larvae, ERR, single cocoon weight, shell weight, shell ratio and filament length. To study magnitude of variability more precisely amongst these 16 strains, their rearings were conducted in a completely randomised design with five replications for each treatment in spring seasons of 1986, 1987 and 198 8 Each replication comprised of 250 worms. (after 3rd moult). Standard rearing techniques recommended by KRISHNASWAMI (1978) were followed in this study. The data were pooled and analysed statistically.

RESULTS AND DISCUSSION

Analysis of variance for eight quantitative traits revealed adequate amount of variability among genotypes. The mean value for all the characters studied together with their critical differences are presented in Table 1. The mean squares for all the characters were significant at 1% probability level, thereby proving that these srtains are ecogeographically divergent and they are quite different in expressing their characters. The comparative discussion with respect to each quantitative character is presented below:

Fecundity: The mean number of eggs was highest in 'J 112' (780.6). However, 'C 108', 'J 122' band 'Pure 81' with egg number of 767.0, 751.4 and 744.8 (Table 1) respectively were at par with former. Fecundity was lowest (605.2) in 'B 38 M'. Fecundity in 'J 112', 'C 108' and 'J 122' in the present

study was more than recorded by earlier workers (ANONYMOUS, 1983).

Larval weight : 'Jam 21', 'B 38P' and 'C 122' with larval weight of 52.50g, 51.78 g and 50.83 g respectively were significantly superior to rest of the genotypes. The lowest weight (41.70 g) was observed in 'B40'. Earlier workers have recorded weight of 55.00 g and 50.00 g for 'Jam 21' and 'C 122' respectively (ANONYMOUS, 1983).

Effective rate of rearing: The yield obtained from 10,000 larvae was highly variable and ranged from 13.868 kg ('Saniish M') to 19.96 kg ('B 38 P'). The number of cocoons obtained from 10,000 larvae was maximum (9084.6) in 'J 122' followed by 'C 122'

TABLE 1. Comparative performance of sixteen silkworm genotypes with respect to 8 quantitative characteristics.

Silkworm genotypes	No. of eggs/ DFL	Wt. of 10 mature larvae(g)	Yield/ 10000 larvae by no.	Yield/ 10000 larvae by wt. (kg)	Single cocoon wt. (g) Y	Single shell wt. (cg)	SR%	Filament length (m)
1	2	3	4	5	6	7	8	9
'B 36'	707.4	46.98	8061.6	17.146	2.11	37.4	17.72	811.8
'B 38 P'	712.8	51.78	8473.8	19.096	2.22	40.4	18.14	878.4
'B 38 M'	605.2	44.98	8518.8	17.625	2.04	38.4	18.81	918.2
'B 40'	662.4	41.70	8252.6	14.746	1.72	29.4	17.01	826.0
'C 108'	767.0	44.64	8764.2	15.930	1.79	31.4	17.50	906.6
'C 110'	692.6	44.70	8320.6	16.940	1.95	34.6	17.71	984.8
'C 122'	692.6	50.80	8787.0	18.854	2.10	37.0	17.62	909.8
'Chang Naung'	644.2	44.46	8122.6	14.762	1.82	31.2	17.10	858.8
'Haulak'	718.4	44.50	8711.6	16.418	1.76	32.6	18.46	1001.4
'Jam 21'	645.2	52.50	8217.4	17.656	2.07	38.4	18.50	986.8
'J 112'	780.6	45.74	8069.4	14.454	1.86	32.2	17.12	775.4
'J 122'	751.4	50.08	9784.6	18.646	1.97	36.2	18.34	837.4
'Pure 81'	744.8	45.08	8684.8	17.556	1.94	33.8	17.44	882.0
'Saniish P'	643.6	47.26	8775.6	18.086	2.05	40.8	19.88	1046.2
'Saniish M'	702.2	49.84	6341.2	13.860	2.15	41.4	19.18	829.0
'Yakwei'	675.8	49.02	8208.0	15.676	1.85	35.6	19.21	950.4
C.D. at								
5%	46.60	1.770	340.61	1.358	0.086	1.913	0.709	62.9
1%	61.25	2.327	447.66	1.785	0.129	2.514	0.932	82.7

(8787.0), 'Saniish P' (8775.6) and 'C 108' (8764.2) which, however, were statistically at par with 'J 122'. 'Saniish M' was found to be the lowest yielder (6341.2).

Single cocoon weight: 'B 38 P' with a cocoon weight of 2.22 g (Table 1) was significantly superior to all other genotypes except 'Saniish M' (2.15 g) whose performance was at par with it. No significant difference was observed amongst 'B 40', 'Haulak' and 'C 108' which produced comparatively light cocoons. Cocoon weight of 'B 36', 'C 122' and 'Jam 21' has improved due to selection and it was more than recorded earlier (ANONYMOUS, 1983).

Single shell weight : 'Saniish M,' 'Saniish P' and 'B 38P' with shell weight of 41.4 cg, 40.8 cg and 40.4 cg respectively were significantly superior to all other genotypes.

Shell ratio: It was less variable amongst the characters studied. 'Saniish P' attained as high a silk ratio as 19.88%. Next to it were 'Yakwei' (19.21%), 'Saniish M' (19.18%) 'B 38 M' (18.81 %), Jam 21' (18.50 %), 'Haulak' (18.46 %), 'J 122' (18.34 %) and 'B 38 P' (18.14%). The lowest shell ratio (17.01 %) was exhibited by 'B 40.' Shell ratio of 17.7% for 'Jam 21' and 19.65% for 'J 122' has been reported by earlier workers (ANONOYMOUS, 1983).

Filament length: It was highest in 'Saniish P' (1046.2m). 'Haulak', 'Jam 21' and 'C 110' with filament of 1001.4m, 985.8m and 984.8m (Table 1) respectively were at par with the former. However, 'J 112' showed the shortest silk filament (775.4m).

The silkworm strains like 'J 112', 'Haulak', 'Yakwei' and 'Chang Naung' currently under field use in Kashmir valley did not exhibit standard performance excepting 'J 122' which showed fairly good performance. The comparative performance of 16 races revealed that 'J 112' and 'Chang Naung' were poor in most of the economic characters, 'J 122' has still retained many good quantitative characters and may be continued for use in seed production. The strains like 'B 38P', 'Saniish P', 'C 122' and 'Jam 21' revealed superiority in most of the economic characters over rest of the races indicating that these have potential for utilization in the industrial seed production.

Presently 'J 112' and 'J 122' (peanut shape cocoons) are being crossed with 'Chang Naung', 'Haulak' and 'Yakwei' (oval shape cocoons) to raise the industrial seed. Since 'J 122', 'Saniish P,' 'B 38 P', Jam 21', and 'C 108' were found retaining considerable vigour, these may be crossed on the basis of their combining ability for industrial seed production. Studies in this line are under progress.

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TWO NEW MEMBERS OF *SCAPTODROSOPHILA* FROM SIKKIM, INDIA (DIPTERA: DROSOPHILIDAE : *DROSOPHILA*)

A. KUMAR & J. P. GUPTA
Genetics Laboratory, Department of Zoology, Banaras Hindu University, Varanasi, India 221 005

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Description of two new species of *Drosophila*, *D.* (*Scaptodrosophila*) *zingiphila*, *D.* (*Scaptodrosophila*) *vazrae* is given. Their taxonomic relationship within the group is also discussed.

(*Key words*: new species, *Scaptodrosophila*)

Sikkim is a small mountainous Indian state in eastern Himalayas. Despite its remarkable physiography, the state remained unexplored for drosophilid fauna until now. It is only very recently some collections have been undertaken in this region. These studies have yielded the occurrence of several interesting species of Drosophilidae (Gupta and Gupta, 1990, 1991 ; Kumar and Gupta 1990a, b).

In order to procure maximum number of flies different methods of collection like bait-trap or net sweeping were employed. Occasionally flies were also collected using aspirator.

This paper deals with the description of two more new species recently collected from the vicinity of Gangtok in Sikkim.

Drosophila (Scaptodrosophila) zingiphila sp. nov.

Average length of the body : 2.55 mm (♂), 2.87 mm (♀).

Head, ♂ ♀ : Arista with 3 dorsal and 2 ventral branches in addition to terminal fork. Antennae with second segment pale brown; third segment lighter. Frons including ocellar triangle pale brown. Orbitals in ratio 7:2:8, anterior reclinate orbital closer to proclinate than to posterior reclinate. Vibrissa single, strong. Palpus yellow, with 3–4 marginal setae. Carina yellow, narrow and high. Face and cheek pale yellow; greatest width of cheek 1/5 greatest diameter of eye. Clypeus brownish. Eyes red.

Thorax, ♂♀ : Mesonotum and scutellum unicolorous, brownish yellow. Thoracic pleura brownish yellow, all 3 sternopleural bristles large. Acrostichal hairs in 8 regular rows. Anterior scutellars nearly parallel; posterior scutellars crossed each other. Prescutellar bristles well developed. Distance between anterior and posterior dorsocentrals 1/4 the distance between two anterior dorsocentrals.

Legs straw yellow. Preapicals on all three tibiae; apicals on first and second tibiae.

Wings, ♂♀ (Fig. 4) : Hyaline, posterior crossvein mildly fuscous. Approximate wing-vein indices: C-index 3.9–4.2; 4V-index 1.6–1.7 ; 4C-index 0.62–0.64 ; 5X-index 1.22-1.25; C_3 fringe 1/3. Haltere pale yellow.

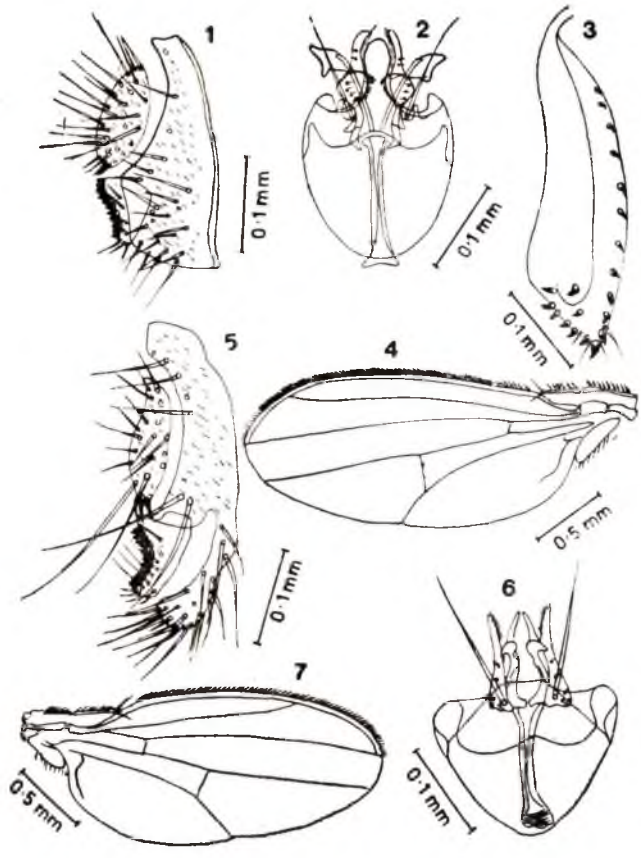

Fig. 1–4. *Drosophila* (*Scaptodrosophila*) *zingiphila* sp. nov.: 1. Periphallic organs; 2. Phallic organs; 3. Egg-guide; 4. Male wing.

Figs. 5–7. *Drosophila* (*Scaptodrosophila*) *vazrae* sp. nov.: 5. Periphallic organs; 6. Phallic organs; 7. Male wing.

Abdomen, ♂♀ : Yellow, tergites with dark brown apical bands.

Periphallic organs (Fig. 1): Epandrium pubescent, broad below, with about 23 bristles along posterior margin. Surstylus triangular, with about 11 black teeth arranged in a concave row and 6–7 small tough bristles. Cercus somewhat elliptical, pubescent, with about 25–27 bristles.

Phallic organs (Fig. 2): Aedeagus broad, straight, with tip rounded. Anterior gonapophysis large, apically narrow and hairy, with about 6–7 sensilla on middle region. Posterior gonapophysis dilated basally, broadened apically. Novasternum with a pair of long apartly placed submedian spines. Ventral fragma rounded distally.

Egg-guide (Fig. 3) : Lobe elongate, with about 17 marginal and 3 discal teeth.

Holotype ♂, INDIA, SIKKIM, Gangtok district, Ranipool, March 1989 (Kumar and Gupta). **Paratype:** 6 ♂♂, 5 ♀♀, same locality and collectors as holotype. Deposited in "*Drosophila* collection", Department

of Zoology, Banaras Hindu University, Varanasi, India and Department of Biology. Tokyo Metropolitan University, Tokyo, Japan.

Relationships: This species closely resembles *Drosophila* (*Scaptodrosophila*) *elenthiensis* Sundaran and Gupta (1991, in press) in body colouration, number of arista branches and in the general pattern of male and female genital structures, but clearly differs from it in having posterior cross vein mildly fuscous (clear in *elenthiensis*), posterior gonapophyses dilated basally and broadened apically (absent in *elenthiensis*), and egg-guide lobe with 17 marginal and 3 discal teeth (with 20 marginal and 6 discal teeth in *elenthiensis*).

Distribution : INDIA

Drosophila (Scaptodrosophila) *vazrae* sp. nov. Average length of the body : 2.48 mm (♂), 2.76 mm (♀).

Head, ♂ ♀ : Arista with 3–4 dorsal and 2 ventral branches in addition to terminal fork. Antennae with second segment brownish yellow; third segment light brown. Frons including ocellar triangle orange brown. Orbitals in ratio 6:3:7, anterior reclinate close to proclinate than to posterior reclinate. Vibrissa single and strong. Palpus orange yellow, with 2 prominent setae. Face and cheek pale tan; greatest width of cheek 1/6 greatest diameter of eye. Carina narrow, high. Clypeus brownish. Eyes red.

Thorax, ♂ ♀ : Mesonotum and scutellum pale brown, much darker in old individuals. Thoracic pleura dark brownish. Acrostichal hairs in 8 regular rows. Anterior scutellars convergent; posterior scutellars crossed each other. Prescutellar bristles not distinguishable. Distance between anterior and posterior dorsocentral 3/5 the distance between two anterior dorsocentrals.

Legs dull yellow. Preapicals on all three; tibiae; apicals on first and second tibiae.

Wings, ♂ ♀ (Fig. 7) : Hyaline. Approximate wing-vein indices: C–index 1.8–2.0; 4V–index 2.35; 4C–index 1.4; 5X–index 1.85; C_3 fringe $\frac{1}{3}$. Haltere white.

Abdomen, ♂ ♀ : 1T yellow, 2T with medially interrupted dark brown band, the remaining tergites completely dark brown.

Periphallic organs (Fig. 5): Epandrium large, pubescent, narrowly projected at lower tip, upper portion with about 5 bristles; lower portion with about 23 bristles, 2 bristles placed near the insertion of surstylus much larger. Surstylus crescent, with about 13 black stout teeth and about 8 bristles behind teeth and 4–5 stout setae below. Cercus narrow, pubescent, with about 18 bristles, 2 lower bristles largest and 3–4 black stout setae at lower tip.

Phallic organs (Fig. 6) : Aedeagus bifid, apically narrowing and pointed. Anterior gonapophysis large, apically tapering and hirsute, with 3 sensilla on lower half. Posterior gonapophysis minute, fused with aedeagus. Novasternum with a pair of long submedian spines. Ventral fragma triangular.

Holotype ♂, INDIA, SIKKIM, Gangtok district, Ranipool, March 1989 (Kumar and Gupta). **Paratype:** 5 ♂♂ 1 ♀, same locality and collectors as holotype. Deposited in "*Drosophila* collection," Department of Zoology, Banaras Hindu University, Varanasi, India and Department of Biology, Tokyo Metropolitan University, Tokyo, Japan.

Relationships : This species closely resembles *Drosophila* (*Scaptodrosophila*) *ambiguifascia* Okada and Carson (1983) with respect to the colouration of antennae, palpi and legs, number of arista branches but distinctly differs from it in having mesonotum and

scutellum pale brown (pruinose grey in *ambiguifascia*), cercus with two unusually large lower bristles and 3–4 black stout setae at lower tip (absent in *ambiguifascia*), aedeagus bifid (fused in *ambiguifascia*), anterior gonapophysis apically hirsute and with 3 minute sensilla on lower half (bare and with 3 apical sensilla in *ambiguifascia*), and ventral fragma triangular (quadrate in *ambiguifascia*).

Distribution : INDIA.

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TWO NEW SPECIES OF THE GENUS *OEDIGNATHA* THORELL (ARANEAE : CLUBIONIDAE) FROM COASTAL ANDHRA PRADESH, INDIA

T. S. REDDY & B. H. PATEL
Department of Zoology, Sir. P.P. Institute of Science, Bhavnagar University
Bhavanagar, Gujarat, India 364 002

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Two new species of spider genus *Oedignatha* Thorell (Clubionidae) viz., *Oedignatha binoyii* sp. nov. and *O. indica* sp. nov. are described and illustrated from Visakhapatnam District of Coastal Andhra Pradesh, India.

(*Key words*: new spiders, *Oedignatha binoyii* sp. nov., *O. indica* sp. nov.)

The first record of Indian *Oedignatha* Thorell (Clubionidae) spiders was made from India by Thorell in 1881 and thereafter, Simon (1897), Strand (1907), Reimoser (1934) and Majumder (1985) have described as many as 11 species from India.

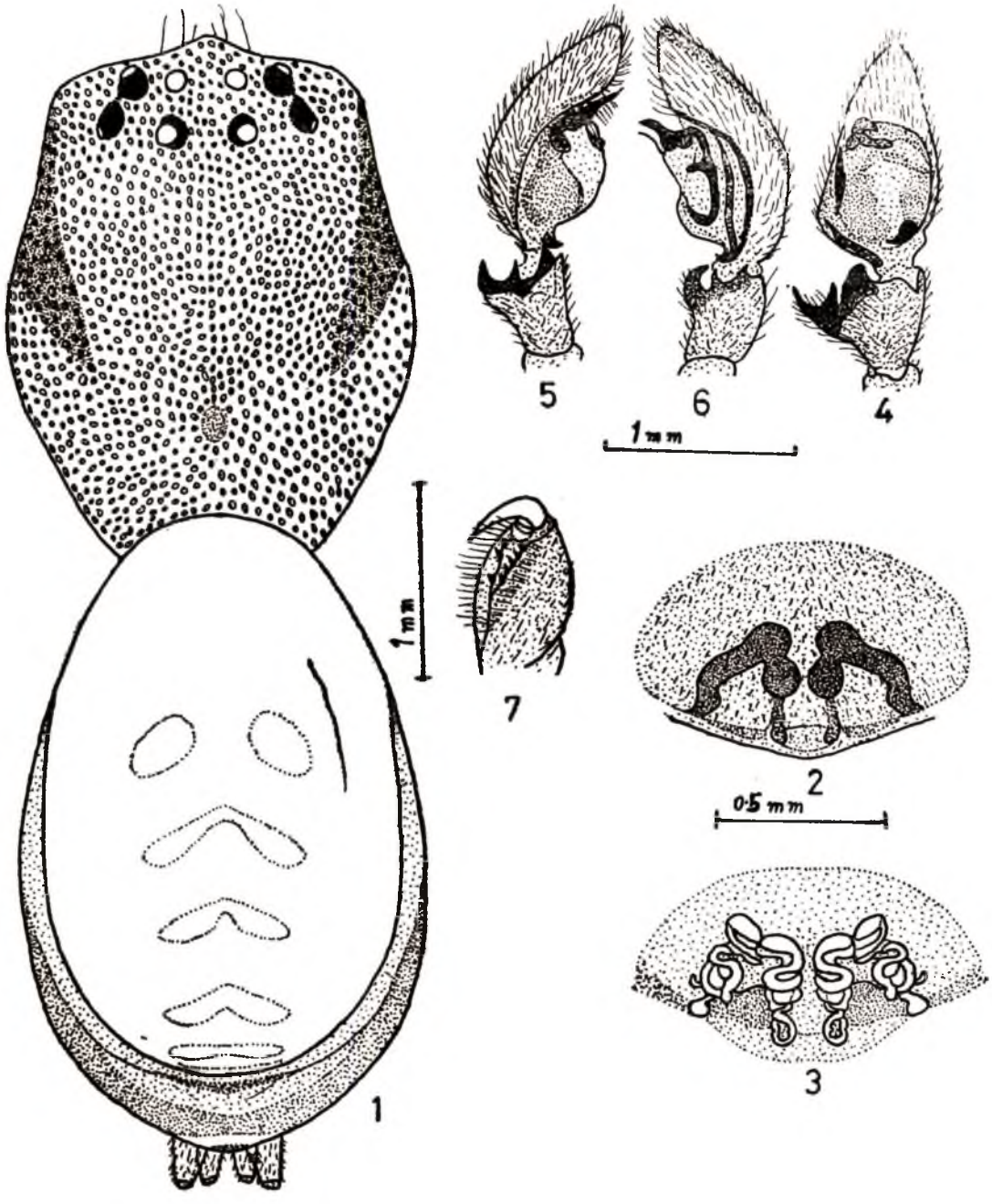
While examining the spider collections made by one of us (TSR) from Coastal Andhra Pradesh, we came across two new species of the genus *Oedignatha*, which are described and illustrated here, making the total number of species to 13 from India.

The type specimens will in due course be deposited in the National collections, Zoological Survey of India, Calcutta.

1. Oedignatha binoyii sp. nov. (Fig. 1-7).

General: Cephalothorax and legs reddish brown, abdomen reddish black and decorated with two longitudinal rows of four pairs of pale patches with white hairs. Total length 5.92 mm. Carapace 3.01 mm long, 2.11 mm wide; abdomen 3.27 mm long, 2.06 mm wide.

Cephalothorax: Oblong, longer than wide, reddish brown, with irregularly arranged small pits. The cephalic shield extending upto the frontal median eyes and a prominent median tubercle situated just below the median frontal eyes in front of the cephalothorax. Thorax provided with central fovea. Eyes in two rows, anterior and posterior. Anterior row of eyes slightly procurved and equal in size; anterior and posterior medians are equal in size. Posterior row procurved, slightly longer than the anterior row; posterior medians slightly smaller than the posterior laterals and placed equidistant from each other. Laterals close to each other. Ocular quad almost square, slightly narrow anteriorly as in Fig. 1. Sternum, oval, reddish brown, clothed with hairs and decorated with irregularly arranged small black pits. Labium reddish brown, longer than wide, slightly depressed at the middle and extends beyond the middle of maxillary lobes. Maxillae reddish in colour, longer than wide, very slightly depressed at the middle, distal end pale, broad and rounded provided with scopulae. Chelicerae large, reddish brown, scopulated distally with chocolate brown hairs; inner and outer



Figs. 1–7, *Oedignatha binoyii* sp. nov. 1. Dorsal view of female (legs omitted); 2. Epigyne; 3. Internal genitalia; 4. Right male palp – ventral view; 5. Right male palp – inner view; 6. Right male palp – outer view; 7. Right chelicera – ventral view.

margins of fang furrow provided with five and three big teeth resp. as in Fig. 7. Legs long, slender, strong and stout. Femora I and II slightly curved and III and IV very little curved. Tibiae and metatarsi I and II provided with eight and six pirs of thin ventral spines respectively. Tarsi relatively long provided with two claws and tenent hairs. Leg formula 1 4 2 3.

Male: Similar to the female and nearly equal in size. Total length 6.00 mm. Male palp as in Figs. 4, 5 and 6.

Abdomen : Oblong, longer than wide, reddish black in colour. Dorsum provided with hard sclerotized shield, decorated with four pairs of pale patches with white hairs arranged mid-logitudinally in two rows as in Fig. 1. Ventral side lighter than the dorsal and not uniformly coloured. Epigyne and internal genitalia as in Figs. 2 and 3.

Holotype One ♀, **paratype** 1♀, *allotype* 1♂ in spirit.

Type-locality: Araku, Dist Visakhapatnam, 18.x.1986. Coll. T. S. Reddy.

Diagnosis: This species resembles *Oedignatha procerula* Simon but it is separated as follows : (i) Anterior row of eyes slightly procurved and anterior and posterior medians are equal in size but in *O. procerula* anterior row of eyes slightly recurved and anterior medians larger than the posterior medians. (ii) Tibiae and metatarsi I and II provided with eight and six pairs of thin ventral spines resp. but in *O. Procerula* tibiae and metatarsi I and II provided with seven and five pairs of ventral spines respectively. (iii) Male palp is also structurally different.

2. **Oedignatha indica** sp. nov. (Figs. 8-15)

General: Cephalothorax black, legs reddish brown, abdomen blackish but decorated with four pairs of pale patches with white hairs arranged in two longitudinal rows. Total length 5.16 mm. Carapace 2.50 mm long, 1.50 mm wide; abdomen 2.88 mm long, 1.45 mm wide.

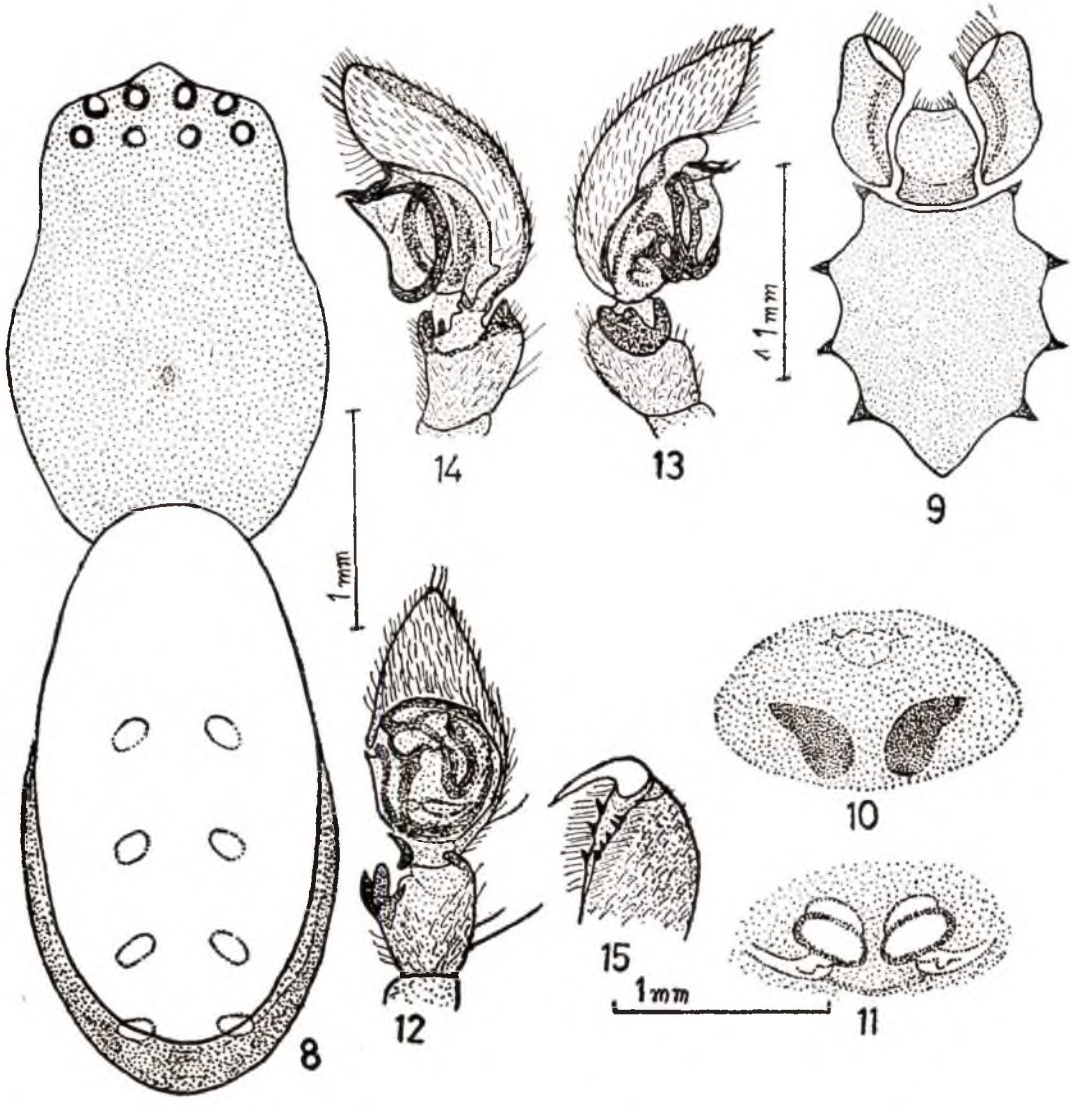
Cephalothorax: Oblong, longer than broad, black, decorated with irregularly arranged small pits. The cephalic shield extended upto the frontal median eyes and a prominent median tubercle situated just below the median frontal eyes in front of the cephalothorax. Thorax provided with central fovea. Eyes in two rows, anterior and posterior. Anterior row slightly procurved; anterior medians are slightly smaller than the anterior laterals and placed equidistant in a row, anterior and posterior laterals are equal in size. Posterior row procurved, slightly longer than the anterior row; posterior medians slightly smaller than the posterior laterals and placed equidistant from each other in a row. Laterals close to each other. Ocular quad almost square, as in Fig. 8. Sternum, oval, reddish black, clothed with hairs and decorated with irregularly arranged small black pits. Labium reddish brown longer than wide and slightly depressed at the middle and extends beyond the middle of maxillary lobes. Maxillae reddish, longer than wide, very slightly depressed at the middle, distal ends pale broad and rounded, provided with scopulae. Sternum, labium and maxillae as in Fig. 9. Chelicerae large, reddish brown in colour, scopulated distally with chocolate brown hairs; inner margin of fang furrow provided with five small teeth and outer margin with three big teeth as in Fig. 15. Legs long and slender, strong and stout. Femora I and II slightly curved and III and IV very little curved. Tibiae and metatarsi I and II provided with seven pairs of thin ventral spines. Tarsi relatively long,provided with two claws and tenent hairs. Leg formula 1 4 2 3.

Male: Similar to the female and practically equal in size. Total length 4.25 mm. Male palp as in Figs. 12, 13, and 14.

Abdomen: Oblong, longer than wide, blackish in colour. Dorsum provided with hard sclerotized shield, decorated with four pairs of pale patches with white hairs, arranged mid-longitudinally in two rows as in Fig. 8 Ventral side lighter than the dorsal and not uniformly coloured. Epigyne and internal genitalia as in Figs. 10 and 11.

Holotype: One ♀ allotype 1 ♂ in spirit.

Type-locality: Anakapalli, Dist Visakhapatnam.



Figs. 8–15, *Oedignatha indica* sp. nov. 8. Dorsal view of female (legs omitted); 9. Sternum, labium and maxillae, 10. Epigyne; 11. Internal genitalia; 12. Right male palp – ventral view; 13. Right male palp – inner view; 14. Right male palp – outer view; 15. Right chelicera – ventral view.

13.x.1985. Coll. T. S. Reddy.

Diagnosis: This species resembles *Oedignatha scrobiculata* Thorell but it is separated as follows: (i) Tibiae and metatarsi I and II provided with seven pairs of thin ventral spines but in *O. scrobiculata* tibiae and metatarsi I and II provided with five and seven pairs of ventral spines respectively. (ii) Dorsum of abdomen provided with hard sclerotized shield, decorated with four pairs of patches with white hairs but in *O. scrobiculata* dorsum of abdomen provided with hard sclerotized shield, decorated with six pairs of white patches extending longitudinally on either side of the mid-dorsal line. (iii) Epigyne and internal genitalia are also structurally different. (iv) Male palp is also structurally different.

ACKNOWLEDGEMENTS

The authors are grateful to Prof. K. B. Tipnis, Principal, Sir. P. P. Institute of Science, Bhavnagar for providing laboratory facilities.

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TWO NEW SPECIES OF THE GENUS *CHORIZOPES* O. P. CAMBRIDGE (ARANEAE : ARANEIDAE) FROM INDIA

T. S. REDDY & B. H. PATEL
Department of Zoology, Sir P. P. Institute of Science, Bhavnagar University, Bhavanagar, Gujarat, India 364 002

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Two new species of spider genus *Chorizopes* O. P. Cambridge (Araneidae) viz., *Chorizopes pateli* sp. nov. and *C. khedaensis* sp. nov. are described and illustrated from Guntur District of Andhra Pradesh and Kheda District of Gujarat State resp. from India

(*Key-words*: two new spiders, *Chorizopes pateli* sp. nov., *C. khedaensis* sp nov.)

The first record of the genus *Chorizopes* O.P. Cambridge (Araneidae) was made from India by Simon in 1895 and thereafter, Tikader (1965), Sadana and Kaur (1973) and Tikader (1975, 1982) have described as many as five species from India. The species *Chorizopes calciope* (Simon) was first placed under the genus *Araneus* by Simon (1895) and later it was correctly placed under the genus *Chorizopes* by Tikader (1982).

While examining the spider collections made from Coastal Andhra Pradesh and Gujarat states, we came across two new species of this genus which are described and illustrated here. This makes the total of seven species of this genus from India.

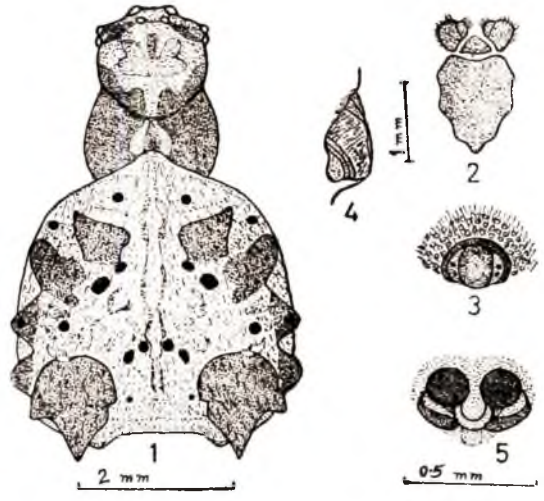
The type specimens will in due course be deposited in the National collectons of Zoological Survey of India, Calcutta.

1. Chorizopes pateli sp. nov. (Figs. 1–5).

General: Cephalothorax black, legs yellow-wish with conspicuous dark brownish bands abdomen greyish with black and yellowish patches. Total length 5.30 mm, carapace 2.30 mm long, 1.70 mm wide; abdomen 3.50 mm long, 3.55 mm wide.

Cephalothorax: Longer than wide, narrowing anteriorly and clothed with white hairs. Cephalic region roundish, highly convex elevated than thoracic region and lighter in colour. All eyes are pearly white, both rows of eyes recurved but anterior row more recurved than the posterior row. Anterior median eyes slightly larger than the posterior medians and posterior medians encircled by black rings. Lateral eyes close to each other and subequal in size as in Fig. 1. Ocular quad nearly as long as wide and slightly wider in front than behind. Sternum heart shaped, pointed behind, black in colour, clothed with pubescence. Labium as long as wide, dark brown with pale distal margin. Maxillae broad and brown with pale tips, provided with distinct scopulae at the end; sternum, labium and maxillae as in Fig. 2. Chelicerae strong, stout, dark brown, provided with prominent boss, inner and outer margins of fang furrow provided with one and three teeth respectively. Legs moderately strong, all segments provided with dark transverse bands, clothed with hairs. Leg formula 1 2 4 3.

Male: Unknown.



Figs. 1–5, *Chorizopes pateli* sp. nov. 1. Dorsal view of female (legs omitted); 2. Sternum, labium and maxillae; 3. Epigyne; 4. Epigyne–lateral view; 5. Internal genitalia.

Abdomen: As long as wide, narrowing anteriorly, clothed with hairs, provided with three pairs of prominent lateral tubercles and anterior mid-dorsally with one pair of prominent tubercle. Posterior end of abdomen provided with one pair of broad, blunt and triangular vertically arranged caudal processes as in Fig. 1. Dorsum of abdomen provided with a distinct mid-longitudinal chalk white band with brown margin and some small brown, black white patches, spots and irregularly distributed sigillae as in Fig. 1. Ventral side dirty brown, posterior end yellowish in colour. Epigyne provided with a short and rounded scop as in Fig. 4. Epigyne an internal genitalia as in Figs. 3 and 5.

Holotype: One ♀ in spirit.

Type-locality: Narasaraopeta, Dist. Guntur, 20.iii.1986. Coll T. S. Reddy.

Diagnosis: This species resembles *Chorizopes tikaderi* Sadana and Kaur but separated as follows: (i) Eyes pearly white, both rows of eyes recurved but in *C. tikaderi* eyes pearly white, anterior row almost straight and posterior row procurved. (ii) Ocular quad nearly as long as wide but in *C. tikaderi* ocular quad longer than wide. (iii) Epigyne and internal genitalia are also structurally different.

2. Chorizopes khedaensis sp. nov.
(Figs. 6–11)

General: Cephalothorax brown, legs and abdomen black. Total length 4.05 mm. Carapole 1.48 mm long, 1.32 mm wide; abdomen 2.88 mm long, 2.28 mm wide.

Cephalothorax: As long as wide, round in front, clothed with pubescence, cephalic region rounded, highly convex and much elevated than thoracic region and lighter in colour. All eyes are pearly white, anterior row recurved, posterior row slightly procurved; anterior medians smaller than posterior medians, posterior medians situated on prominent base as in Fig. 6. Ocular quad longer than wide. Sterum heart shaped, pointed behind, reddish brown in colour, clothed with pubescence and hairs. Labium

wider than longer, riddish brown in colour with pale outer distal margin. Maxillae broad, reddish brown, provided with distinct scopulae. Sternum, labium and maxillae as in Fig. 7. Chelicerae strong and stout reddish; inner and outer margins of fange, furrow provided with three teeth each. Legs moderately strong, blackish, clothed with hairs; femora, patellae and tibiae III and IV provided with yellowish transverse bands at the anterior ends.

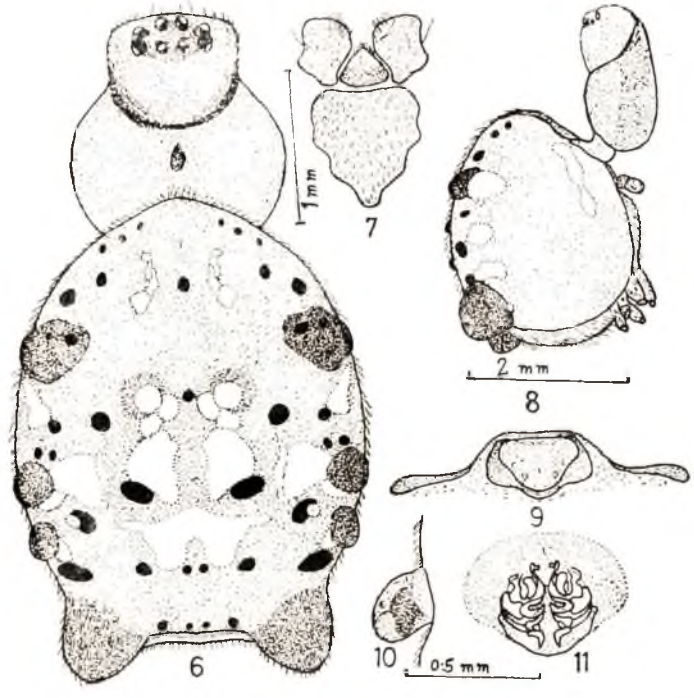
Male: Unknown.

Abdomen: Black, longer than wide, clothed with grey hairs, posterior end of abdomen provided with one pair of lateral blunt tubercles. Dorsum of abdomen provided with irregularly arranged chalk white patches as in Fig. 6. Ventral side black in colour and laterally provided with three irregular round chalk white patches as in Fig. 8. Epigyne provided with a rounded and stout scape as in Fig. 10. Epigyne and internal genitalia as in Figs. 9 and 11.

Holotype: One female **paratype**: One female in spirit.

Type-locality: Navagam, Dist. Kheda, Gujarat, 16. ix. 1990 Coll. Patel.

Diagnosis: This species resembles *Chorizopes calciope* (Simon) but it is separated as follows: (i) Posterior end of abdomen provided with one pair of lateral blunt tubercles but in *C. calciope* posterior end of abdomen provided with one pair of lateral blunt tubercles and one caudal tubercle. (ii) Abdomen laterally provided with three chalk white patches but in *C. calciope* abdomen provided with one chalk white patch only. (iii) Epigyne provided with a broad and stout scape but in *C. calciope* epigyne



Figs. 6–11, *Chorizopes khedaensis* sp. nov. 6. Dorsal view of female (legs omitted); 7. Sternum, labium and maxillae; 8. Abdomen - lateral view; 9. Epigyne; 10. Epigyne - lateral view; 11. Internal genitalia.

plate like. (iv) Internal genitalia are also structurally different.

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The authors are grateful to Prof. K. B. TIPNIS, Principal, Sir P. P. Institute of Science, Bhavnagar for providing laboratory facilities.

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NEW PODAPOLIPID MITES (PODAPOLIPIDAE: ACARI) INFESTING GRASSHOPPERS IN TAMIL NADU, INDIA

M. MOHANASUNDARAM
Department of Agricultural Entomology, Agricultural College and Research Institute, Madurai, India 625 104

(*Received* 30 *June* 1991)

Six species of Podapolipidae (Acari) are recorded on grasshoppers from Tamil Nadu, India, of which five are new to science. The mites are *Podapolipoides acarideus* sp. nov., *P. acridivorus* sp. nov. *P. bacillus* Berlease, *Podapolipus ichthyus* sp. nov., *P. pseudoichthyus* sp. nov. and *P. pteronicheus* sp. nov.

(*Key words*: grasshopper mites, Podapolipidae, *Podapolipus*, *Podapolipoides*)

An intensive survey of mites associated with grasshoppers in Tamil Nadu was taken up during 1990. Field collected grasshoppers were periodically screened for the presence of mites on the body as well as in the tracheae and air sacs. Whenever mites were encountered, they were collected, cleared and mounted in Hoyer's medium for study and the host grasshopper identified. The study of the mites collected revealed several species of Podapolipidae and Erythraeidae of which many are new to science. The Podapolipid mites studied are reported hereunder. The type and paratype slides are deposited in the Acarology Collections of the Department of Agricultural Entomology, Tamil Nadu G. D. Naidu Agricultural University, Coimbatore-641 003, India. All measurements given in the descriptions are in μm.

1. **Podapolipoides acrideus sp. nov.**
(Figs. 1 to 3)

Female: Elongate, dirty white to light brown, 500 long 250 wide, with an anterior wing like bifurcate lobe on either side; the anterior propodosoma covering the gnathosoma and base of the legs. Gnathosoma about 50 long, without any setation, cheliceral stylet 16 long. Leg, one pair, about 60 long including coxae, segments clear, tarsal tip with two thick setae of which one is hook like, femoral seta 12 long. Dorsum and ventrum of idiosoma fairly smooth without any ornamentation or setae.

Larva : Not known

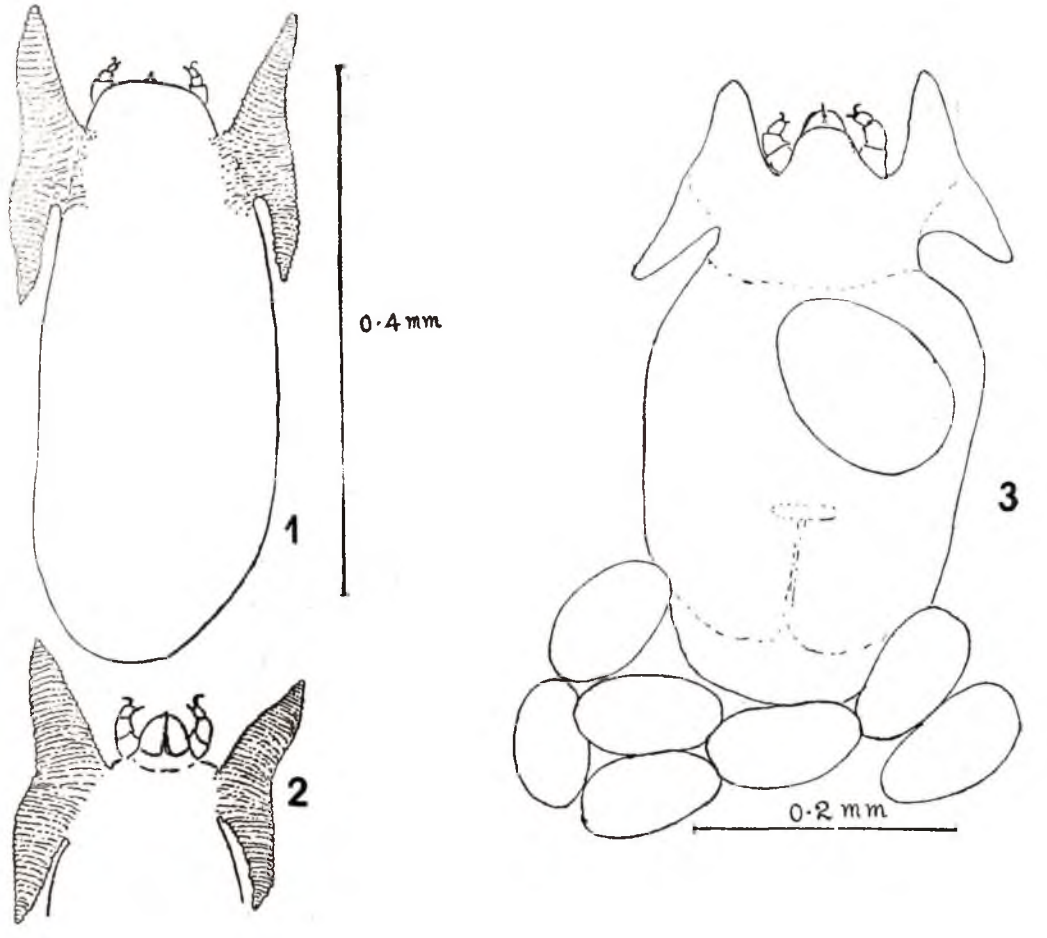
Types: A ♀ holotype marked on slide along with other ♀♀ and four paratype slides with ♀♀ and eggs without larvae: INDIA: TAMIL NADU; Madurai, 20.xii.1990 ex. *Attractomorpha obscura* (Acrididae: Orthoptera) S. Suresh Coll.

Remarks : This species is differentiated from other species of *Podapolipoids* by the elongated form, the wing-like anterior lobes having crincles and by the smooth body surface.

Relation to host: This mite was found attached to the hind wing base of the grass-hopper.

2. **Podapolipoides acridivorus** sp. nov.
(Figs. 4–11)

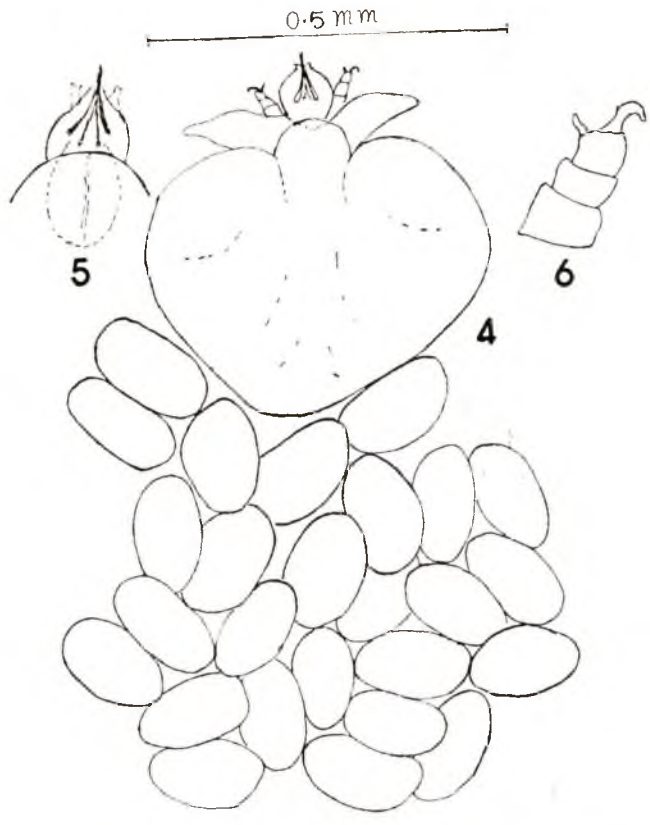
Female: Nearly globular in shape, dirty white to light brown in colour while alive;



Figs. 1–3. *Podapolipoides acrideus* sp. nov; 1. Very young female - Dorsal view; 2. Very young female– Anterior ventral view; 3. Adult female with eggs – extruded.

450–500 wide, 480–500 long; with a lobe on either side of the gnathosoma and a median blunt lobe covering the base of the gnathosoma. Gnathosoma about 40 long 50 wide stylets prominent 24 long. One pair of legs with 3 clear segments, tarsus ending in a short straight, thick blunt spine laterally and a thick hook terminally; femoral seta 16 long; no other setation on the leg segments. Body with faint wrinkles, otherwise dorsum and ventrum smooth devoid of ornamentation and setae.

Larva: 200 log, 120 wide, with three pairs of legs. Gnathosoma 30 long, 40 wide, with a pair of seta in the anterior dorsal aspect measuring 4 and 18 long. Idiosoma with four clear plates; propodosoma with seta V_1 12 long; V_2 8 long setae Sc_2 75 long; metapodosoma and opisthosoma with two short setae each 14 long; dorsum smooth; ventrum smooth, coxae devoid of setae; pygideal tip with setae h_1 18 long and terminally with a pair of long whip like setae, h_2 360 long. Leg I with tarsus ending with sensory setae and without empodium; leg II



Figs. 4–11. *Podapolipoides acridivorus* s. nov. 4. Adult female with eggs extruded; 5. Gnathosoma of female; 6. Leg of female;

with one seta in the fumer and one on the tibia, tarsus ending in thick spine like projections, leg III with a seta on tibia and the tarsus ending in three thick spines.

Types : A holotype ♀ marked on slide and five paratype slides with ♀♀ and larvae; INDIA TAMIL NADU : Madurai, 20.xii. 1990 ex *Attractomorpha* sp. (Acarididae : Orthoptera) S. Suresh Coll.

Relation to host: This mite is found attached to the wing veins in the folds of the hind wing of the grasshoppers.

3. **Podapolipoides bacillus** Berlese (1911)

Material studied: ♀ just moulted from nymph, INDIA: TAMIL NADU: Madurai, 8.xii.1990 ex *Attractomorpha* sp. (Acarididae: Orthoptera) S. Suresh Coll.

Relation to host: The mites found in the wing base, dirty white in colour.

4. **Podapolipus ichthyus** sp. nov. (Figs. 12–14)

Female : Sac-like, white, body 470 long, 610 wide; body with scale like projections ventrally, dorsally fairly smooth, gnathosoma 100 long with clear stylets, other structures atrophied, bigger specimens of females were also encountered which become hardened in to a white irregular mass. Females were larviparous.

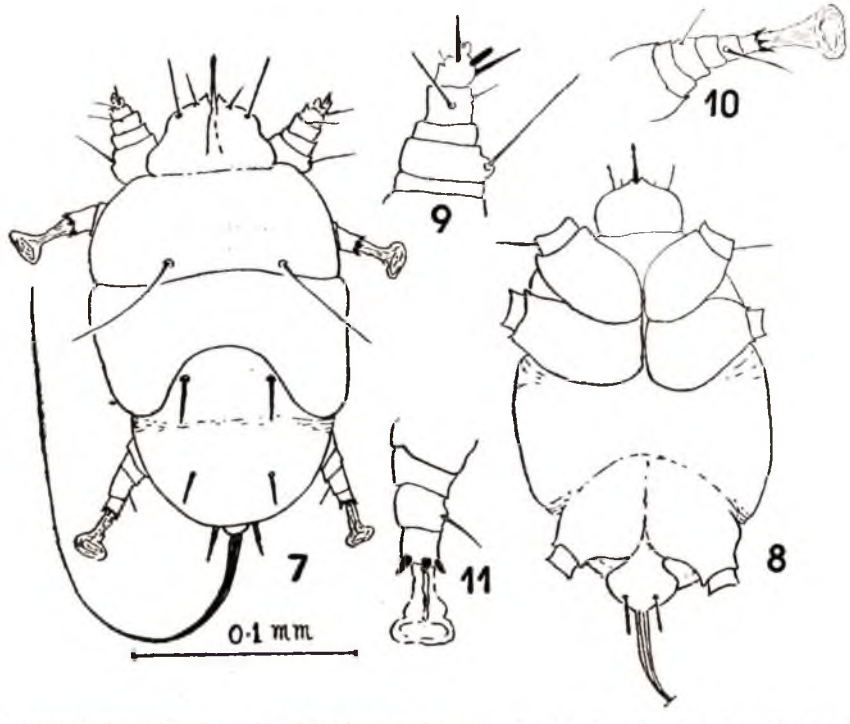
Larva: Body 180 long including gnathosoma, 140 wide; gnathosoma 50 long, 46 wide; dorsally a 32 long seta on the sides; ventrally with 3 pairs of setae on the palpal segments which are closely fused with the base of chelicerae.

Dorsum of larva: Propodosoma with two pairs of short setae measuring about 4 each in the anterior region and a pair of 60 long setae in the posterior region. Opisthosoma with 3 pairs of short setae, the anterior and middle pair measuring about 6 long while the posterior pair about 2 long the caudal tip ending in a pair of long flagellate setae closely approximated with each other, measuring about 320 long and ending into a fine point.

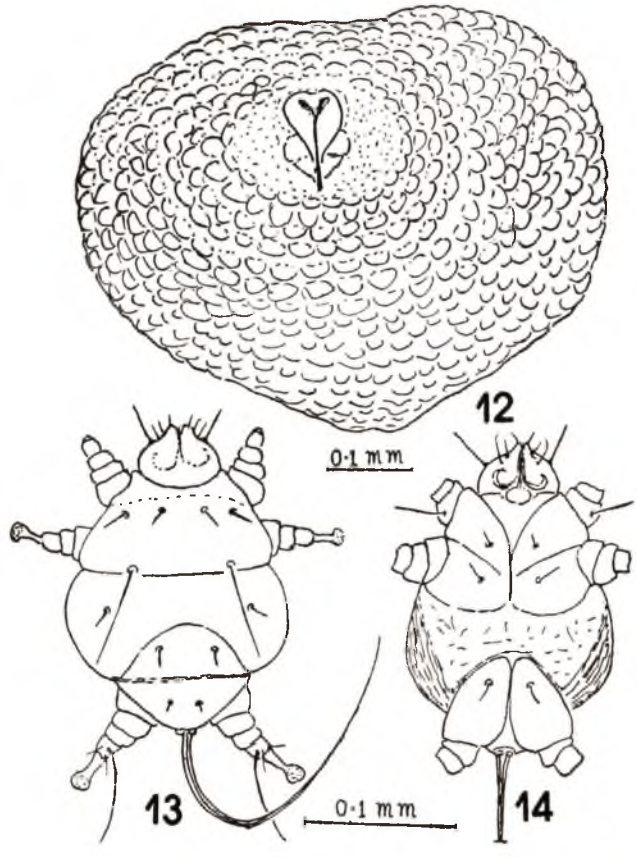
Ventrum of larva: Devoid of any setation except for a short seta measuring about 6 in each coxal base. Legs 3 pairs; anterior two pairs projecting forward and outward; third pair at the caudal end pointing backward. Setation on the legs I to III : coxae 1, 1, 1; trochanter, 0, 0 0; femora, 1, 0, 0; genua, 0, 0, 0; tibiae, 2,2,3; tarsi, 3,3,3. Tarsi I ending bluntly with a short fleshy lobe, tarsi II with an elongated pretarsus ending in a fleshy lobe, tarsus III with a 30 long seta apart from two short setae and ending in a pretarsus with fleshy lobe.

Types: A holotype ♀ marked on the slide with several hexapod larvae, two paratype slides with ♀♀ and larvae; INDIA: TAMIL NADU: Coimbatore, 19.viii.1988, ex *Spathosternum prasiniferum* Walk. (Acrididae), M. Mohanasundaram Coll.

Relation to host: The hexapod larvae were encountered on several species of acridid grasshoppers while the gravid saclike female was noted only on *Spathosternum*



7. Dorsal view of larva; 8. Ventral view of larva; 9. Leg 1; 10. Leg 2; 11. Leg. 3;



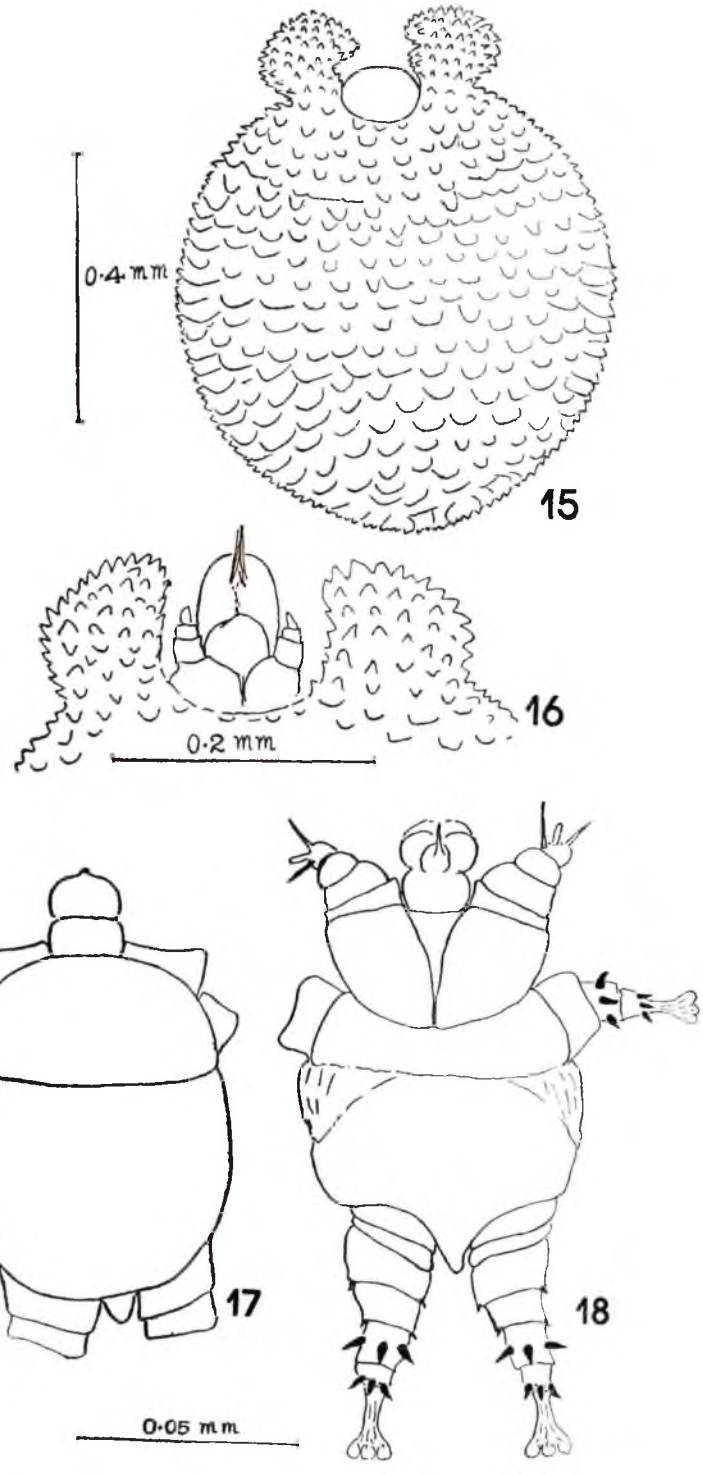
Figs. 12–14. *Podapolipus ichthyus* sp. nov. 12. Adult female - Ventral view; 13. Dorsal view of larva; 14. Ventral view of larva.

prasiniferum. The mites are purely parasitic, females are sessile and found attached to the body of the grasshopper by its gnathosoma, while the hexapod larvae were found both attached as well as moving over the body of the hosts.

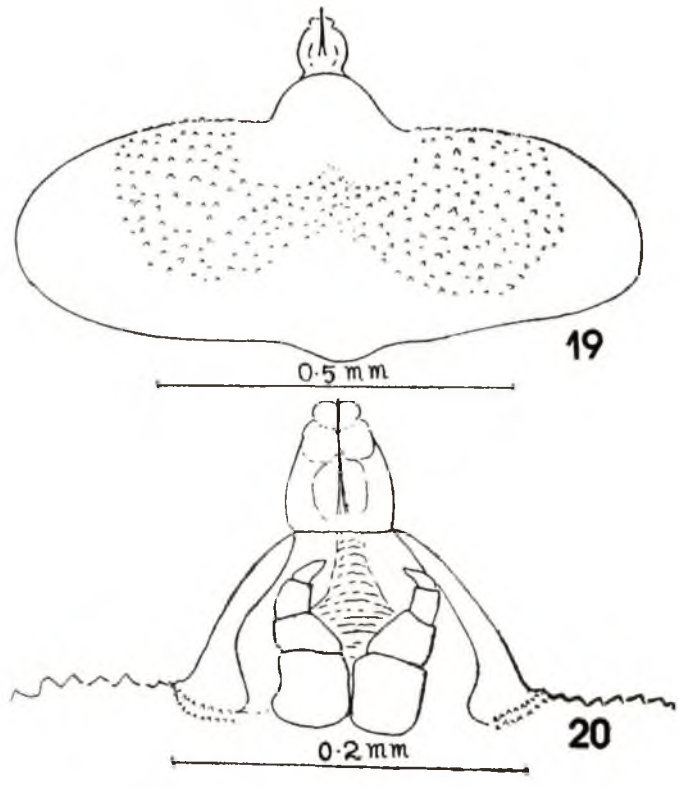
Remarks: The new species is differentiated by the sac-like female with scale like protuberanses on its ventral surface. The larvae resemble that of *Peripolipus muraii* Husband (1984) but can be differentiated by their setal pattern and size.

5. **Podapolipus pseudoichthyus** sp. nov. (Figs. 15–18)

Female: Globular, white with a rough body surface body 800 long, 560 wide, cuticle with scale like projections both on the dorsal and ventral surfaces, gnathosoma about 60 long, with clear stylets 20 long; devoid of any setation, anterior end of the body covering on either side of gnathosoma as two blunt lobes, anterior portion of propodosoma covering base of gnathosoma and legs, one pair of legs 47 long, just below gnathosoma with faint segmentation and without any setation. Several larvae found inside the body and hence the females are viviparous in nature.



Figs. 15–18. *Podapolipus pseudoichthyus* sp. nov. 15. Dorsal view of female; 16. Ventral view of anterior end of female; 17. Dorsal view of female; 18. Ventral view of male.



Figs. 19 & 20. *Podapolipus pteronicheus* sp. nov. 19. Dorsal view of the female; 20. Ventral view of anterior end of female.

Male: Body 100 long including gnathosoma, 60 wide, gnathosoma 20 long, 16 wide, devoid of any setation. Dorsally idiosoma divided into a propodosoma and metapodosoma, dorsal cuticle smooth, ventrum smooth without any setation. Leg I tarsus ending with a solenidion and two sensory setae and without an empodium, leg II and III with empodium and with three short blunt spines each of the tibia and tarsus.

Types: A holotype ♀ on slide and two paratype slides with ♀♀ and larvae; INDIA : TAMIL NADU : Madurai 29. xii. 1990, ex *Spathosternum* sp. (Acrididae : Orthoptera) S. Suresh, Coll.

Remarks: This new species resembles *Podapolipus ichthyus* n. sp. in its cuticular pattern with scale like projection, but differentiated from it by its anterior lobes and the pair of legs.

Relation to host: The gravid globular females were found attached to the wing base of the grasshoppers while the males were found on the general body surface of their host.

6. Podapolipus pteronicheus sp. nov. (Figs. 19 and 20)

Female: Laterally elongated, dirty white to light brown, 880–900 wide, 380 long, with an anterior dorsal projection covering

the gnathosoma and propodosoma; gnathosoma 85 long, cheliceral stylet 80 long; no setation on the gnathosoma; leg 95 long including coxa, segments obscure no setae on legs. Dorsum of idiosoma with a few well separated scale like projections on either side of the mid line in the anterior 2/3 area; ventrum with such projections in a restricted area on either side of the base of gnathosoma; the rest of the ventrum smooth.

Larva : Not known.

Type: A holotype ♀ marked on slide and four paratype slides each with ♀♀ INDIA : TAMIL NADU : Madurai, 14.xii.1990 ex *Attractomorpha* sp. (Acrididae : Orthoptera) S. Suresh Coll.

Remarks: This species is differentiated from *Podapolipus grassi* Berlese (1911) by its shape and dorsal ornamentation.

ACKNOWLEDGEMENTS

The author express his sincere thanks to Dr. R. W. Husband, Adrian College, Michigan, USA for his generous supply of reprints of his works on this group of mites and for critically going through the manuscript and giving expert suggestions for placement of the species.

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THREE NEW SPECIES OF RHYNCAPHYTOPTID MITES (ACARI : ERIOPHYOIDEA) FROM NORTHEAST INDIA

B. DAS* & S. CHAKRABARTI
Biosystematics Research Unit, Department of Zoology, University of Kalyani, Kalyani, India 741 235

(*Received* 9 *March* 1991)

Three new species of eriophyid mites under the family Rhyncaphytoptidae, viz., *Acarhyncus dendrocalami* sp. nov. from *Dendrocalamus* sp., *Diptacus duabangiphagus* sp. nov. from *Duabanga grandiflora* (Roxb. ex DC.) Walp., and *Diptacus cephalanthi* sp. nov. from *Cephalanthus naucleoides* DC. are described. Relationships of the new species with other known species are discussed.

(*Key words* : Acari, Rhyncaphytoptidae, taxonomy, new species, Northeast India)

Burnihat valley lying at an altitude of circa 400 m above m.s.l. on the eastern slopes of the Khasi hills in Meghalaya was explored for eriophyid mites in October-November, 1985. The study yielded two species under *Diptacus* Keifer (1951) and one under *Acarhyncus* Keifer (1959a) that were new to science. The genera *Diptacus* and *Acarhyncus* were also reported for the first time from India. Descriptions, drawings and relevant notes on the three new species are included in this paper.

The type slides are deposited presently in the collection of the Biosystematics Research Unit, Department of Zoology, University of Kalyani, Kalyani 741235, India. Range of measurements given in the description are based on the holotype and nine paratypes and are in micrometres.

Acarhyncus dendrocalami sp. nov. (Figs.1–6).

Body 185.6–199.5 long, 62.4–70.0 wide, robust fusiform and a little compressed dorsoventrally. Colour in life pinkish. Rostrum large, 35.0–44.1 long, bent down perpendicularly to body; chelicerae large proximally turned down at right angles. Shield 59.0–65.0 long, 64.9–75.0 wide, semicircular in anterior outline, with a broad anterior lobe over rostrum base; from below apex of lobe, a thin filamentous extension curving down gradually over chelicerae; shield surface without prominent longitudinal lines, but with short broken lines extensively dorsally and laterally; a few granules along lateral border of shield; dorsal tubercles reduced, lying 19.3–20.9 apart and 9.3 ahead of rear shield margin and with minute setae. Foreleg 41.8–44.1 long, femur 9.3–14.0 long without any seta; patella 4.6–7.0 long, with seta 32.5–35.0 long; tibia 11.6 long with seta 9.3–11.0 long located somewhat laterally on distal 0.25; tarsus 7.0–9.3 long with two setae 25.5–32.5 and 20.9 long; claw 9.3 long, almost straight, tapering, with tip unknobbed; feather claw apparently divided, with 10–15 bushy rays on each side. Hindleg 35.0–39.4 long; femur 9.3–21.6 long; patella 4.6–7.0 long without any seta; tibia 8.1–9.3 long; tarsus 7.0–9.0 long with setae 11.6 and 25.5–27.5 long; claw 9.3 long, other details as in the foreleg. Forecoxae

* Correspondence: S. Chakrabarti.

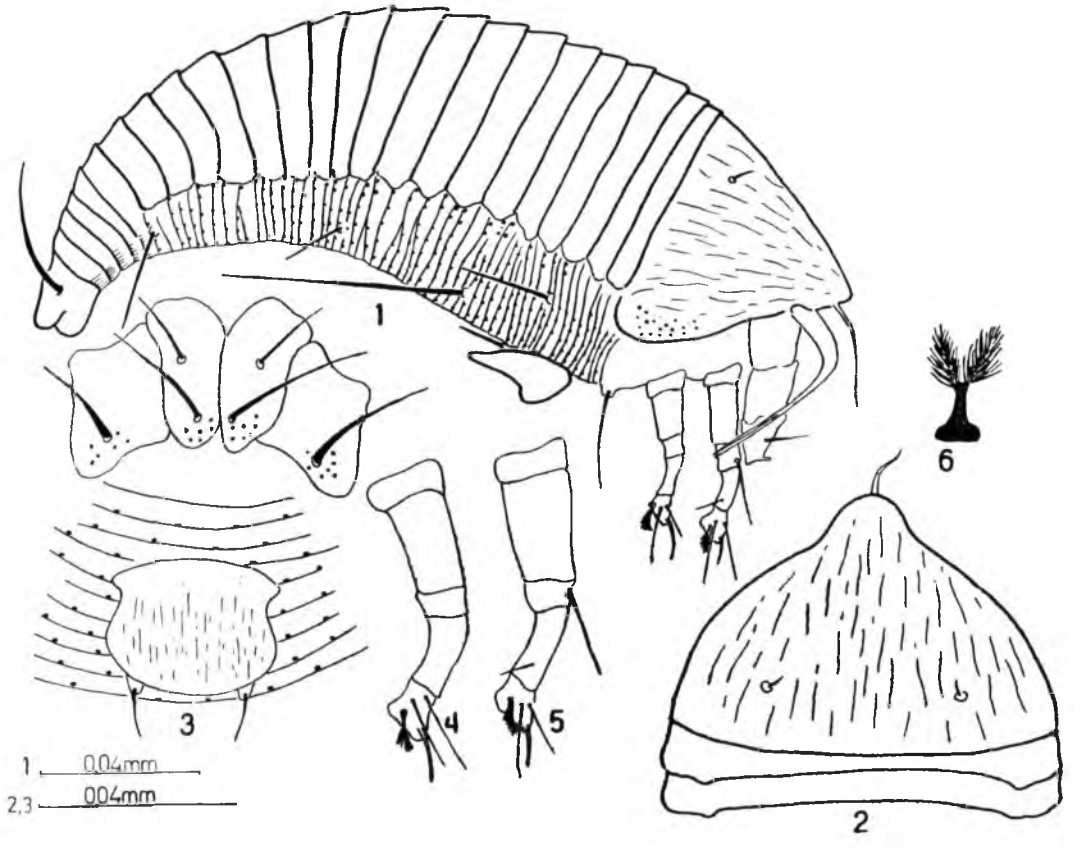


Fig. 1–6 *Acarhyncus dendrocalami* sp. nov. Female. 1. Lateral view of body; 2. Dorsal view of shield and anterior tergite; 3. Coxae and genitalia, 4. Hindleg, 5. Foreleg; 6. Featherlaw.

elongate, widely contiguous along a moderate sternal line; coxal surface with few scattered granules around bases of second and third setiferous tubercles; first coxal setae 25.0–30.0 long, lying well below anterior approximation; second coxal setae 35.0–51.0 long, located opposite rear end of sternal line, inner to diagonal line through first and third coxal setae; third coxal setae 38.0–42.3 long.

Abdomen compressed dorsoventrally with a wide, shallow longitudinal trough on dorsum, that extends full length of thanosome, bounded on either side by low, wide ridge, thanosome with 16–18 broad smooth tergites and 50–55 narrow microtuberculate sternites; sternites with fine rounded microtubercles on rear margins, these becoming irregular and coarse laterally towards confluence with tergites; telosome smooth above and microstriate below; lateral seta 16.2-25.5 long on about sternite 6–7 from rear shield margin; first ventral seta 49.7–58.0 long on about sternite 19–20; second ventral seta 14.0–27.8 long on about ring 33–34; third ventral seta 27.8–35.0 long on about rings 5–6 from base of caudal lobes; caudal seta present; accessory seta not apparent; genitalia 23.2–27.8 wide, 16.2–18.6 long; coverflap with obscure markings as seen on the shield surface; internal apodeme

of normal anterior width; genital setae 9.3-14.0 long.

Males : Observed, a few only, about 170.0 long and 65.0 wide. Genitalia 25.0 wide.

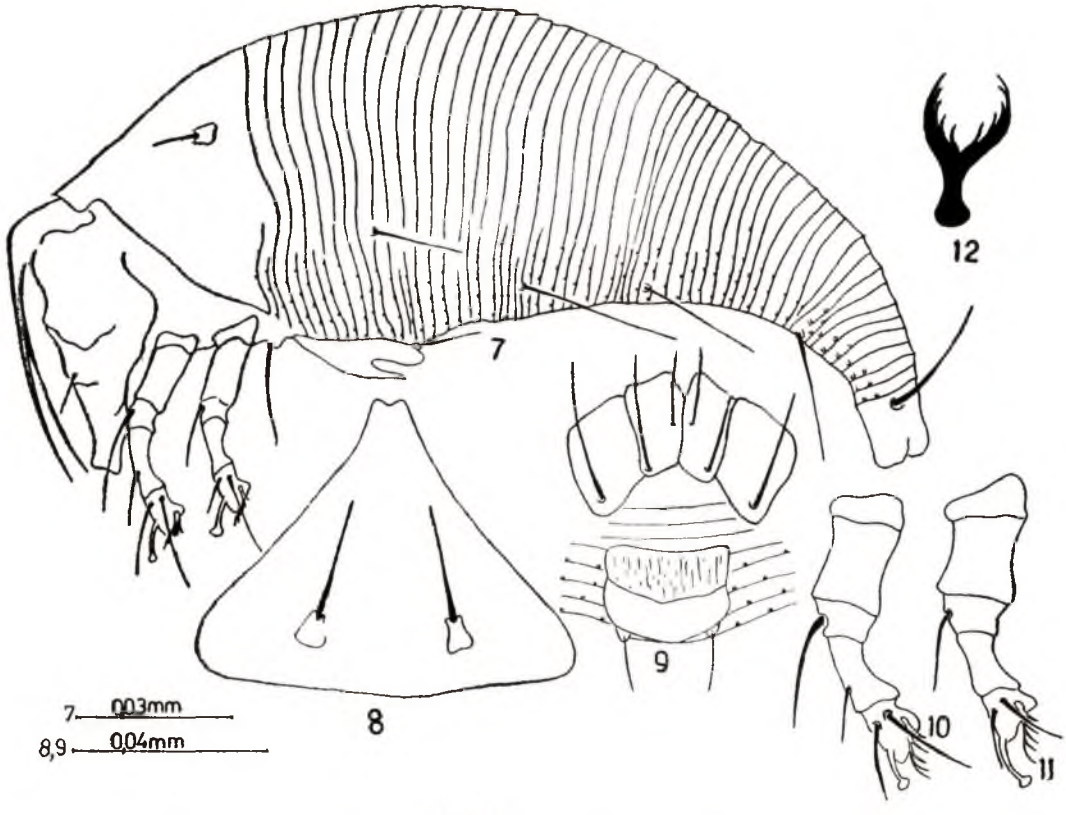
Material studied : **Holotype** Female (marked), on slide (No.964/60/85), INDIA : MEGHALAYA : Burnihat, 17.x.85, ex. *Dendrocalamus* sp. (Poaceae), coll. B. Das **Paratypes:** 10 females and a few males on slide bearing holotype and two other slides (Nos. 965-966/60/85), data as in holotype.

Relationship with host plant: Mites found wandering apparently as harmless vagrants on undersurface of leaves causing no damage.

Remarks: Both *Acarhyncus dendrocalami* sp. nov. and *A. filamentus* Keifer (1959a), the type species are from Poaceous hosts and share a characteristic featherclaw and anterodorsal shield projection. But the latter species that was obtained from North America differs mainly from the former species in having the femoral and patellar setae on the hindleg, less pronounced dorsal setae, coxal area with striations and dista area of female genital coverflap smooth.

Diptacus cephalanthi sp. nov. (Figs. 7–12).

Body 178.6–197.2 long, 45.0–48.0 wide, robust, spindle form, pinkish in colour with whitish dusty wax on body surface, when alive. Rostrum large, 44.1–51.0



Figs. 7–12. *Diptacus cephalanthi* sp. nov. Female. 7. Lateral view of body; 8. Dorsal view of shield; 9. Coxae and genitalia; 10. Foreleg; 11. Hindleg; 12. Featherclaw.

long, bent downwards with subapical seta 9.3 long. Shield 39.4–46.4 long, 43.0–45.0 wide, triangular in shape with a broad truncated, anterior extension over the rostrum base; shield surface smooth; dorsal tubercles oblong, early 35.0 apart and about 4.6 ahead of rear shield margin, dorsal setae directing cephalad 9.3 long. Foreleg 44.1–46.4 long; femur 9.3–12.2 long without seta; patella distinct, 4.6–6.5 long with seta 32.5–42.0 log; tibia 11.6–16.2 long, width a seta 9.2–11.6 long located in distal 0.25 part; tarsus 9.3 long with two setae 23.2-28.7 long and 13.9 long; claw 7.0 long, knobbed; featherclaw divided with five rays on a side. Hindleg 39.4–44.1 long; femur 9.3–11.6 long without any seta; patella 5.8–7.0 long with a seta 9.3 long; tibia 9.3 long without a seta; tarsus 8.5 long with a long seta of 20.8–23.2 and a short seta of 6.0; claw 9.3 long; other details as in foreleg. Forecoxae broadly contiguous along inner margins with a weakly developed sternal line; first coxal setae 10.0 long lying at about level of centre of forecoxae; second coxal setae 16.2 long, lying further apart than first coxal setae and at rear angle of forecoxae; third coxal setae 34.8 long, located little below transverse line passing through second coxal setae; both coxal surface smooth.

Abdomen with wide, faint middorsal ridge from rear shield margin till about 0.5 anterior distance of dosrum; this ridge and a pair of equally faint subdorsal ridges secreting wax, although no thickening of ring margins discernible; thanosome with about 50–54 smooth, wide tergites and about 64–66 narrow sternites with rounded microtubercles aligned on rear ring margins; telosome bare dorsally and with obscure rounded microtubercles ventrally. Lateral seta 13.9–25.0 long on about sternites 6–9; first ventral seta 34.8–55.0 long on about sternite 40; third ventral seta 21.0–30.0 long on about sternite 66 or rings 7–8 from base of caudal lobes; caudal seta present, accessory seta absent. Genitalia 32.0 long and 35.0 wide with a basal and of short, curved longitudinal lines; internal apodeme of normal width; genital seta 13.9–16.2 long.

Males: Not observed.

Variation: Few females representing the same species collected from coffee tree (*Coffea* sp.), an additional host plant have the chelicerae curved down gradually instead of sharply and have stronger lateral abdominal seta.

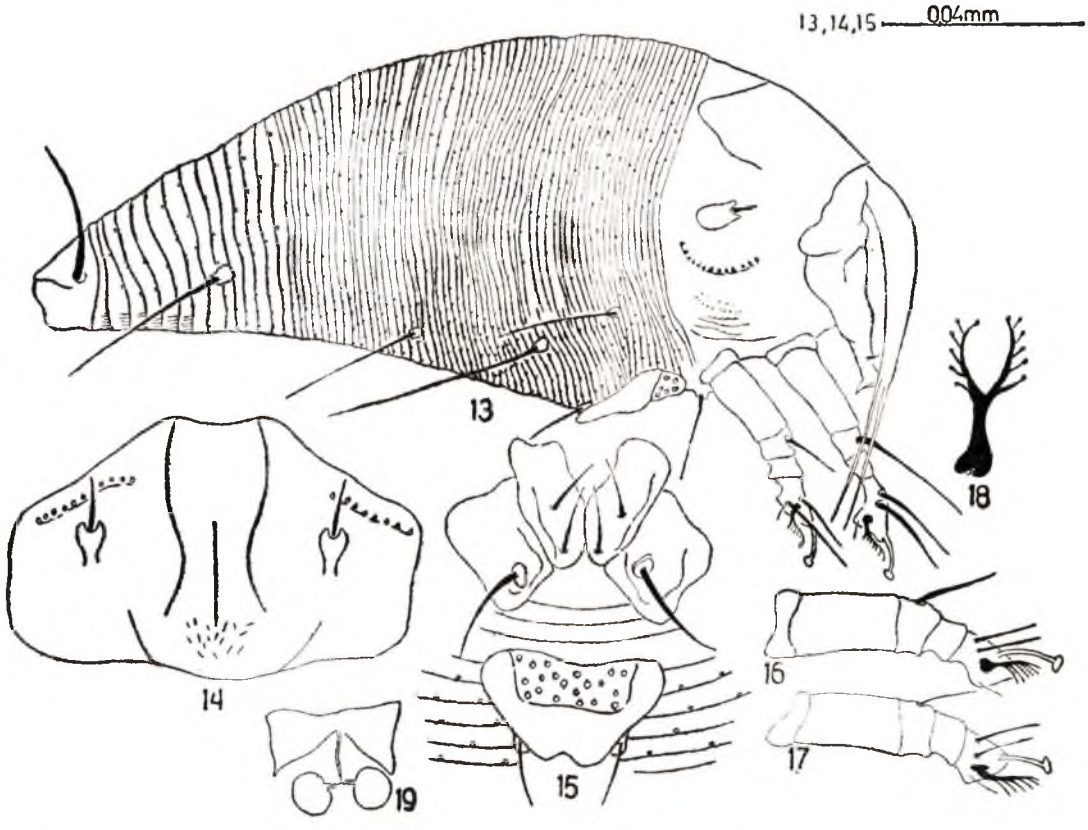
Material studied : **Holotype** : Female (marked) on slide (No. 1146/97/85), INDIA: MEGHALAYA : Burnihat, 18.xi.1985, ex. *Cephalanthus nauclaoides* DC. (Rubiacea), coll. B. Das. **Paratypes** : 16 females on slide bearing holotype and three other slides (Nos. 1147–1149/97/95), data as in holotype; 5 females on one more slide (No. 1166/101/85), ex. *Coffea* sp. (Rubiaceae) 24.xi.1985, INDIA : MEGHALAYA: Shillong (Botanic Gardens) coll. B. Das.

Relationship with the host: Mites were found as vagrants on leaf undersurface.

Remarks : *Diptacus cephalanthi* sp. nov. has a smooth shield and five rays on a side in the featherclaw. In this respect it is very close to *D. rabunensis* Davis (1966) and *D. mazuriensis* Boczek (1966), but varies from both in the nature of coxal contiguity and rough textured genital coverflap. It differs from *D. duabangiphagus* sp. nov. described in this work by wider tergites, smooth dorsal shield and presence of foretibial seta.

Diptacus duabangipgagus sp. nov.
(Figs. 13–19)

Body 171.7–194.0 long, 69.6–75.0 wide, robust spindle form, purple and with flakes



Figs. 13–19. *Diptacus naucleoides* sp. nov. Female 13. Lateral view of body. 14. Dorsal view of shield; 15. Coxae and genitalia; 16. Foreleg; 17. Hindleg; 18. Featherclaw; 19. Internal genital structures.

of whitish wax when alive. Rostrum elongate, sac like and bent downwards; subapical seta present. Chelicerae large and curved down over the rostrum. Oral stylets of long form. Shield 32.5-37.1 long, 64.9–70.0 wide, roughly pentagonal in dorsal view, trunctated anteromedially and projecting very slightly over rostrum; shield design of sparse lines; median line present on the posterior 0.6 part of shield, ending in many short strokes ahead of rear shield margin; admedian lines sinuate, curving out from anterior shield margin and terminating abruptly ahead of rear margin; rear central part of shield appearing raised and defined posteriorly by a curved semicircular line; lateral lobes of shield bearing a few curved dotted lines; a row of spinous microtubercles present just below dorsal tubercles; dorsal tubercles rather large, bulbous with basal axes transverse, lying nearly 17.0–24.0 ahead of shield margin and 37.1–39.0 apart from each other; dorsal setae 4.6–5.8 long pointing cephalad. Foreleg 41.8–46.2 long; femur 13.7–16.2 long, devoid of seta; patella 4.6–7.0 long with a seta 34.8–46.0 long; tibia 4.6–7.0 long without a seta; tarsus 9.3–11.6 long with two dorsal setae 34.8–37.1 and 32.5–34.8 long and a short ventral seta; claw 7.0–9.8 long and with knobbed apex; featherclaw divided, with six short rays on each side. Hindleg 32.5–37.5 long; femur 13.9–16.2 long without a

seta; patella 4.6–9.3 long, with a seta 9.3–11.6 long; tibia 4.6 long without a seta, tarsus 7.0–8.1 long, with two dorsal setae 13.7–13.9 and 23.0 long respectively and one short ventral seta; claw 9.3–9.8 long; other characters as in the foreleg. Forecoxae connate posteriorly along a short sternal line; first coxal setae thick, 16.2–20.9 long situated below anterior coxal approximation; second coxal setae 13.9–16.2 long, closer together than first coxal setae, located just above lower end of forecoxae; third coxal setae 30.2–34.8 long, lying little below transverse line passing through second coxal setae; first and second coxal setae point cephalad, while third coxal setae point caudad. Coxal surface smooth but for a few faint wavy lines.

Abdomen characterised by narrow uniform rings; dorsum with a faint median and a pair of subdorsal ridges; ridges not noticeably thickened but wax secreting as observed in living condition; thanosome with about 59–67 tergites and equally numerous sternites; tergites and sternites microtuberculate; microtubercles on sternites more closely placed than those on tergites, granular and lie along posterior ring margins; tergal microtubercles of same size as on sternites; telosome with faint microtubercles dorsally and microstriae ventrally. Lateral seta present 23.0–27.9 long on about sternite 7–9 from the rear shield margin; first ventral seta 37.1–53.4 long on about sternite 16-21; second ventral seta 27.8–37.1 long on about sternite 35–38; third ventral seta 34.8–37.5 long on about sternite 69–67 on ring 9–10 from the base of caudal lobes; caudal seta present; accessory seta absent. Genitalia 23.2–25.3 wide and 16.2–18.5 long; coverflap posteriorly emarginate with a broad basal band of large granules distally smooth; genital apodeme as figured. Genital seta 10.0 long.

Males: Observed 157.8 long and 68.0 wide; genitalia 20.9 wide and 11.6 long Genital seta 9.0 long.

Material studied : **Holotype** : Female (marked) on slide (No. 1080/82/85), INDIA : MEGHALAYA : Burnihat, 1.xi.1985, ex. *Duabanga grandiflora* (Roxb. ex. DC.) Walp. (Lythraceae), coll. B. Das **Paratypes** : 20 females and a few males on slide bearing holotype and four other slides (Nos. 1080-1084/82/85), data as in holotype.

Relationship with the host: Mites were found widely dispersed as vagrants on undersurface of young leaves.

Remarks : There appear to be two groups of species within *Diptacus* as regards shield design. In one, the pattern is reticulate, while in the other there may be obscure longitudinal lines or such lines absent. Both *Diptacus dubangiphagus* sp. nov. and *D. cephalanthi* sp. nov. whose description preceded clearly belong to the latter group. Other species in the same group include *D. calicoryli* (Keifer, 1943), *D. rubra* Keifer (1959b), *D. georgiana* Davis (1964), *D. rabunensis* Davis (1966), *D. mazuriensis* Boczek (1966), *D. crenatae* Kadono (1984). All these species however, differ from both *D. duabangiphagus* and *D. cephalanthi* by the absence of forecoxal contiguity and by restriction to host families Fagaceae and Betulaceae. As such *D. duabangiphagus* is readily distinguishable from all other species in the genus by absence of the foretibial seta and the row of spinous microtubercles on the lateral area of the shield.

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BRIEF COMMUNICATION

STUDIES ON HAEMOCYTES DURING METAMORPHOSIS IN *ODENTOPUS VARICORNIS* (DIST.) (HEMIPTERA: PYRRHOCORIDAE)

N. RAMALINGAM, P. CHANDRAN & M. RAJASEKARA PANDIAN
Department of Zoology, Annamalai University, Annamalainagar, India 608 002

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The total and differential haemocyte counts in this insect during its metamorphosis indicate the existence of a significant linear increase in haemocyte populations suggesting their role in nutrient supply and cellular defense. The involvement of prohaemocyte, plasmatocyte, adipohaemocyte and granular haemocyte in metamopphosis has been discussed.

(*Key* words: haemocytes, metamorphosis, *O. varicornis*)

Studies on haemocyte population have shown that the flow of haemolymph, amount of diet, state of nutrition, age and stage of development and sex are some of the factors responsible for variation in total haemocyte counts in insects (JONES, 1962; WHEELER, 1963; BAHADUR & PATHAK, 1971). However, information on changes in the percentage of different haemocytes during post embryonic development appear to be inadequate and the present investigation deals with the THC and DHC during metamorphosis in a Hemipteran insect *O. varicornis*.

The counting of free haemocytes was done by using a haemocytometer. The total haemocyte counts (THC/mm^3) were determined by the method of KOLMER *et al.* (1969) using the formula $X/4 \times 10 \times y$; where X = total number of chamber, 10 = depth of the chamber, Y = dilution. The differential haemocyte counts (DHC) were made by examing stained blood films under microscope as suggested by VINSON (1971).

It is evident from Table 1 that THC is progressively increasing during different stages of post - embryonic development reaching a peak level in adult stage. Table 2 reveals that the maximum number of prohaemocytes in the II nymphal instar has decreased significantly in the fourth instar. Again the number of these haemocytes increased slightly in the V instar. Plasmatocytes exhibit a steady increase upto IV nymphal instar followed by a gradual decrease in the subsequent stages of development. The adipohaemocyte counts show an increasing trend in the number of these haemocytes upto last nymphal instar followed by decrease in adult stage. The granular haemocyte counts indicate that these haemocytes increase progressively from II nymphal instar to adult stage.

It has been pointed out that the linear increase in haemocyte counts during developmental stages of insects is a wide spread phenomenon (BAHADUR & PATHAK, 1971; HAZARIKA & GUPTA, 1987).

In the present study it has been reported that the total haemocyte counts of *O. varicornis* have increased continuously during post embryonic development. These observations are consistant with those

reported for several insects including *Blatella germanica* (HAZARIKA & GUPTA, 1987) and such an increase in haemocyte population appears to be related to an increasing demand for nutrient supply and cellular defense.

Further, the number of prohaemocytes in *O. varicornis* has decreased significantly during third and fourth nymphal instars, reaching a percentage value of 6.33 at fourth nymphal instars followed by a gradual increase during subsequent stages of development. A similar trend has been observed in *Drosophila melanogaster* (RIZKI, 1957) and *Blatella germanica* (HAZARIKA & GUPTA, 1987). These observations indicate that the decrease in the counts of prohaemocytes during third and fourth nymphal instar stages of *O. varicornis* appears to be due to their transformation to plasmatocytes and types of haemocytes.

The quantity of plasmatocytes has increased to a level 48.5 percentage in IV nymphal instar followed by a significant decrease in

TABLE 1. Total haemocyte counts in *O. varicornis* during its metamorphosis.

Stage of post embryonic development	THC* per mm^3	
	Range	Mean S.E.
III	750 — 1750	1050 ± 116
IV	1500 — 2750	2025 ± 174
V	2250 — 4000	3125 ± 187
Adult male	3500 — 5250	4225 ± 174
Adult female	5000 — 9500	6625 ± 446

* Data represent mean values of twenty measurements.

TABLE 2. Differential haemocyte counts in percentage in *O. varicornis* during its metamorphosis.

Stage of post embryonic development	Types of haemocytes*			
	PHC	PLC	AHC	GHC
II	43.33 ± 0.81	29.67 ± 0.69	13.33 ± 0.77	13.67 ± 0.62
III	17.83 ± 0.98	44.50 ± 1.12	19.00 ± 0.94	18.67 ± 1.28
IV	6.33 ± 0.65	48.50 ± 0.77	25.17 ± 0.83	20.00 ± 0.82
V	11.50 ± 0.31	23.00 ± 1.22	38.83 ± 1.28	26.67 ± 1.50
Adult	16.00 ± 0.78	20.67 ± 1.28	26.17 ± 2.63	37.16 ± 1.14

PHC — Prohaemocyte; AHC — Adiopohaemocyte;
GHC — Granular haemocyte; PLC — Plasmatocyte;

* Data represent mean values of twenty measurements.

the adult stage, as it has been reported for *Rhodnius prolixus* (JONES, 1967) and it may be related to higher phagocytic activity of these cells, particularly at the time of moulting. This inference gains support from the findings of WIGGLESWORTH (1933) on *Rhodnius prolixus* in which plasmatocytes become numerous during each moult, when they injest dead cells and tissues.

The present study has revealed that the number of adipohaemocytes has increased to a maximum level of 38.8% during the development of nymphal instars, probably due to mitotic activities followed by a decrease in adult stage (26.17%) which may be related to the utilization of these cells for the catabolic activities of the adult individual.

The DHC of granular haemocyte in *O. varicornis* have revealed the existence of continuous and linear increase in the quantity of these cells during metamorphosis as it has been reported for *Blatella germanica* (HAZARIKA & GUPTA, 1987) and such an increase in the population of these cells may be correlated with the growing demand for cellular immunity since post embryonic development involves histomorphological changes leading to adult organization.

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BRIEF COMMUNICATION

TOXICITY OF SOME INSECTICIDES TO *CURINUS COERULEUS* MULSANT (COLEOPTERA : COCCINELLIDAE), AN INTRODUCED PREDATOR OF THE SUBABUL PSYLLID

J. DIRAVIAM & C. A. VIRAKTAMATH
Department of Agricultural Entomoloy, University of Agricultural Sciences, Bangalore, India 560 065

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Representatives of different groups of insecticides were tested for their toxicity to adults of an introduced coccinellid predator, *Curinus coeruleus* Mulsant for the management of subabul psyllid *Heteropsylla cubana* Crawford. Among the eight insecticides tested, dichlorvos (0.1%) and nicotine sulphate (0.1%) were comparatively safer, registering a mortality of 60% and 66.67%, respectively after 72 hours. The other candidate insecticides namely, monocrotophos, fenvalerate, malathion, carbaryl, cartap hydrochloride and ethofenprox were found to be highly toxic to the predator.

(*Key words: Curinus coeruleus*, *Heteropsylla cubana*, insecticide toxicity)

The ladybird beetle, *Curinus coeruleus* Mulsant, an important predator of the subabul psyllid *Heteropsylla cubana* Crawford has been introduced into different parts of the world wherever *H. cubana* has gained entry (SINGH, 1988). In order to develop an integrated pest management system for the control of *H. cubana*, there is a need to determine the toxicity of different groups of insecticides against adult *C. coeruleus*.

Earlier, SUDARMADJI (1988) reported that cyhalothrin (0.2%), monocrotophos (0.2%) and dimethoate (0.2%) were toxic to *C. coeruleus* in the field upto three days after application. This present study was conducted to know the susceptibility of *C. coeruleus* to eight different insecticides.

Uniform aged adults of *C. coeruleus* were collected along with *H. cubana* infested twigs from subabul field located behind the Veterinary College, University of Agricultural Sciences, Bangalore and were used for this study.

Subabul twigs infested with *H. cubana* were placed in Petri-plates (9.5 cm diameter) and were sprayed with 1 ml of the spray solution using a Potter's tower at constan pressure of 1.09 kg/cm^2. Water was sprayed which served as the control. The sprayed Petri-plates were dried under fan for 15 minutes and 10 adult beetles were released on each Petri-plate. The Petri plate was covered with muslin cloth and secured with a rubber band. The treatments including control were replicated thrice and all the treatments were fed with fresh psyllids daily. The treated and control were then placed in a BOD incubator at a constant temperature of 25 ± 1°C.

Observations were made at 24 h, 48h, and 72 h after treatment. Corrected mortality percentages were transformed by angular transformation and analysed statistically using analysis of variance (COCHRAN & COX, 1950.)

The mortality after 24, 48 and 72 h after treatment due to different insecticides are

presented in Table 1. After 72 h, monocrotophos (0.05%), carbaryl (0.1%), malathion (0.1%) and ethofenprox (0.02%) were highly toxic to *C. coeruleus* causing 100% mortality. Similar results were obtained by SEKEROGLU & VYGUN (1980) for monocrotophos against *Cryptolaemus montrouzieri* Mulsant, registering 100% mortality after 20 h. SATHPATHY *et al.* (1968) reported 91.1% mortality of *Menochilus sexmaculatus* (Fabricius) due to carbaryl while LINGAPPA *et al.* (1978) reported 100% mortality of *M. sexmaculatus* due to malathion (0.1%), which were similar to the present study.

Fenvalerate (0.01%) registered a mortality of 83.33% and cartap hydrochloride (0.05%) registered 80.0% mortality. Nicotine sulphate (0.1%) and dichlorvos (0.1%) were comparatively safer with a toxicity of 66.67% and 60%. SINGH *et al.* (1988) observed nicotine sulphate to be harmless to *Coccinella septempunctata* Linnaeus, while RAMESH-BABU & AZAM (1987) reported that dichlorvos (0.1%) was the safest insecticide against *C. montrouzieri* with only 20% mortality after 24h.

TABLE 1. Toxicity of selected insecticides to *Curinus coeruleus* adults.

Treatment	Concentration %	Mean per cent mortality after treatment		
		24 h	48 h	72 h
dichlorvos	0.10	13.33^{ab} (17.71)	46.67^{b} (42.99)	60.00^{b} (50.94)
malathion	0.10	96.67^{d} (83.86)	100.00^{d} (90.00)	100.00^{e} (90.00)
monocrotophos	0.05	100.00^{d} (90.00)	100.00^{d} (90.00)	100.00^{e} (90.00)
carbaryl	0.10	100.00^{d} (90.00)	100.00^{d} (90.00)	100.00^{e} (90.00)
fenvalerate	0.01	33.33^{be} (31.00)	76.67^{c} (65.85)	83.33^{be} (70.78)
ethofenprox	0.02	56.67^{e} (49.22)	96.67^{cd} (83.86)	100.00^{e} (90.00)
cartap hydrochloride	0.05	26.67^{be} (30.00)	50.00^{b} (45.00)	80.00^{be} (67.86)
nicotine sulphate	0.10	26.67^{be} (30.00)	43.33^{b} (40.07)	66.67^{b} (60.00)
control (water spray)	—	0.00^{a} (0.00)	0.00^{a} (0.00)	0.00^{a} (0.00)
CD (P=0.05%)		22.82	19.42	24.78

Values followed by the same alphabet in a column are not significantly different from one another.

Values in parentheses are angular transformed values.

ACKNOWLEDGEMENTS

The authors are thankful to Mr. V. T. SANNAVEERAPPANAVAR for his help in conducting these studies.

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BRIEF COMMUNICATION

EFFICACY OF A SIMPLE DEVICE USED FOR CONTINUOUS REARING OF *SPODOPTERA LITURA* F.

P. H. VARTAK, S. N. MUKHERJEE & R. N. SHARMA
Entomology Section, National Chemical Laboratory, Pune, India 411 008

(*Received* 5 *May* 1991)

A device for continuous rearing of *Spodoptera litura* F. was developed. The technique eliminates handling of individual larva, thereby reducing chances of contamination from diseases as well as disturbance of larval feeding pattern. Cleaning is facilitated and the diseased or dead larvae are automatically segregated.

(*Key words :* laboratory rearing, mass rearing, castar leaves, fabrication, sawdust, perspex, thermocole)

Spodoptera litura F. a polyphagous pest of importance, is an ideal experimental material for research and hence effective rearing of this insect under laboratory conditions is of great importance. Rearing of this insect after the III larval instar presents numerous problems. The Nuclear Polyhedrosis Virus is taking a big toll. An attempt was made to design and fabricate an apparatus to take care of the above problem in mass rearing programme.

The apparatus was fabricated using perspex and thermocole sheets as shown in Fig.1. The dimensions of the chambers A and B are 30 × 20 × 20 cm. Each chamber has provision for accommodating a thermocole sheet with perforations at regular intervals. These can be covered by sliding (removable) perspex sheet whose edges fit snugly into the corner channels in both chambers. Both the chambers are filled with sawdust upto 3 cm from the bottom and are held firmly together with an elastic band. A bouquet of castor leaves whose stems are dipped into a conical flask containing water is placed in chamber B. In order to prevent the larvae from migrating upwards, a mixture of petroleum jelly and liquid paraffin (1:1) is applied to the lower half of both chambers and the adjustable (sliding) perspex sheets. The larvae are released in chamber A, and the apparatus is covered with muslin cloth. After a period of 30 min the movable perspex sheets can then be put back in their former positions and the larvae in chamber A which did not migrate are disarded. Chamber A is now cleaned and the sawdust in it is sterilized in the oven at 70°C for 30 min. It can now be reused. After the food in chamber B is exhausted, chamber A is furnished with fresh whorl of leaves, and starving larvae from B are allowed to migrate to A through the perforations as shown earlier. The process can be continuously repeated, taking care to rinse the perspex parts with 10% formalin every 24h as a precaution. Different larval instars (III instar onwards) with varying density were used as treatment. In each case 100 larvae (III instar onwards) without any food constituted the controls. Each experiment was replicated 10 times. The data was analysed by 'F' test.

It is evident from experimental data shown in Table 1 that the apparatus described above

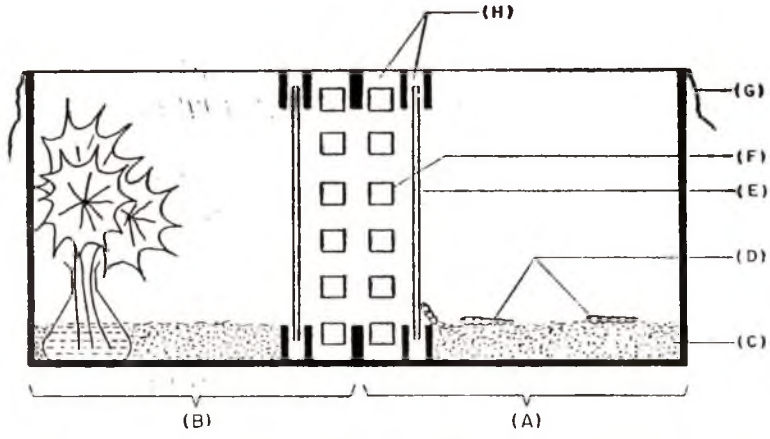

Fig. 1 Diagrammatic representation of cross section of cage for continuous rearing of *S. litura*. A. Chamber for releasing larvae; B. Chamber containing fresh leaves; C. Saw dust; D. Larvae; E. Perspex sheet; F. Thermocole sheet with perforations; G. Muslin cover; H. Groove.

can be successfully used for segregating healthy and active larvae in test laboratory populations. No significant difference was found in the migration between larvae of different instars. This suggests that the migration occurred as the result of starvation towards the food source. However, there was a significant difference when the migrations were compared to control treatments.

Table 1 also shows that there was a significant difference in the effective segregation/migration between the population sizes tested. The greater the population size the more effective the segregation and migration from chamber A to B. This is definitely advantageous for regular handling for experimental and/or maintenance purposes. Preliminary work has shown that a horizontal separator, as used in case of silkworm

TABLE 1: Migration of different larval instars of *Spodoptera litura*.

Number of larvae released in chamber A	% movement of different instars to chamber B (Mean ± SE)			
	III	IV	V	VI
25	74.8 ± 3.16^{a}	76.0 ± 3.04^{a}	78.0 ± 4.35^{a}	76.4 ± 3.75^{a}
50	78.6 ± 2.91^{ab}	78.2 ± 1.80^{ab}	82.2 ± 2.97^{ab}	80.8 ± 3.09^{a}
100	84.8 ± 1.84^{bc}	85.9 ± 2.59^{bc}	87.4 ± 2.37^{bc}	86.3 ± 1.68^{b}
250	92.4 ± 1.15^{d}	94.4 ± 0.62^{d}	94.7 ± 0.96^{d}	94.4 ± 1.08^{d}
500	95.7 ± 0.77^{de}	96.44± 0.66^{de}	96.34± 0.59^{de}	96.56± 0.34^{d}
100 (Cotrol)	16.7 ± 2.74^{f}	14.5 ± 2.27^{f}	18.22± 2.43^{f}	14.2 ± 2.22^{f}

[1] Data are average of 10 replications.

Mean followed by the same alphabet are not significantly different 'F' test (p = 0.5%).

rearing was not successful in this case. In the present technique, individual handling of larvae can be avoided and cleaning of the rearing containers can be done more easily and effectively. The pupae can be finally sieved out and placed in suitable containers (we used glass aquaria) for adult emergance and egg laying.

Since the first two instars feed less, tend to remain together and hang in clusters with silken thread on being disturbed making their collection tedious, the apparatus can be used to advantage from the 111 instar onwards.

The apparatus and methodology described here for easy rearing of *S. litura* can also be used for other lepidopteran pests such as *Achaea janata* L., *Spodoptera littoralis* Boisd., and *Mythimna separata* (Walker).

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BIOLOGICAL STUDIES ON BLUE BUTTERFLY, *JAMIDES ALECTO* (FELDER) (LYCAENIDAE: LEPIDOPTERA), A MAJOR CARDAMOM CAPSULE BORER IN KARNATAKA

JASVIR SINGH, B. GOPAKUMAR[1] & D. KUMARESAN[1]
Division of Entomology, Indian Cardamom Research Institute Regional Research Station,Spices Board, Saklespur, India 573 134

(*Received* 5 *May* 1991)

The biology of a serious cardamom capsule borer, *Jamides alecto* (Felder), was studied under laboratory conditions. The female blue butterfly lays 45 to 62 eggs in 5-7 days on cardamom panicles, flower buds and capsules. The eggs batch in 5-6 days with 71.43% hatchability. The larval period is completed in 20-25 days with 4 moults. The larvae bore and feed on flowers, flower buds and tender capsules. A V instar larva consumes 2-3 immature capsules per day. The prepupal period lasts for 2 days followed by 12-13 days of pupal stage. The female adult longevity is 8-12 days whereas it is 6-8 days for male. The total life span is 50-58 days at 16.79 ± 0.13°C (min) and 25.38 ± 0.42°C (max) temperatures.

(*Key words:* cardamom capsule borer, *Jamides alecto* (Felder), biological studies)

INTRODUCTION

Cardamom (*Elettaria cardamomum* Maton) is subject to attack by a number of insect pests which cause considerable economic losses. The caterpillars of *Conogethes punctiferalis* (Guen.), *Jamides* sp. nr. *alecto*, *Jamides* sp. and beetles of *Onthophagus coorgenis*, *Onthophagus* sp. and *Thammurgides cardamomi* bore into the cardamom capsules and damage them. (SIDDAPPAJI & REDDY; 1972: KUMARESAN *et al.*, 1988). *Jamides alecto* (Felder) is a serious capsule borer and has been reported from Karnataka only (SIDDAPPAJI & REDDY, 1972). The caterpillars of this blue butterfly bore into and feed on the inflorescence, flower buds and immature capsules. The incidence of the pest is high after the commencement of rains during June to October which is a difficult period for pesticide application. Detailed studies on the biology, morphometrics and larval feeding habits of *J. alecto* undertaken at this Regional Research Station are reported here.

MATERIALS AND METHODS

Laboratory reared adults were released in plastic jars (12 × 12 cm) and provided with 10% honey solution. Two bearing panicles of cardamom with flowers were also kept inside the jars. The eggs that were laid on panicles, flower buds and capsules were removed daily and placed on cardamom leaves in Petri-dishes (10 cm diameter). Each neonate caterpillar was transferred to separate plastic jars (7 × 11 cm) and a panicle with flower buds and tender capsules was provided. Observations on fecundity, incubation period, hatchability, longevity (in both sexes) and mortality at different age intervals were noted. Morphometrics of eggs, larvae, pupae and adults were recorded with ocular and stage micrometers. The maximum and minimum temperature during

[1] Indian Cardamom Research Institute, Spices Board, Myladumpara, India 685 553.

TABLE 1: Observations on the age intervals of cardamom capsule borer, *Jamides alecto* (Felder).

Parameter	Egg	Larval instars					Pre-pupa	Pupa	Adult	
		I	II	III	IV	V			Male	Female
No. of individuals	56	40	24	16	14	14	14	12	4	6
Developmental period (days)	5—6	4	3—4	3—4	4—5	6—8	2—00	12—13	6—8	8—12
Morphometrics Length (mm)	0.835 ±0.012	1.817 ±0.032	2.286 ±0.084	3.720 ±0.143	6.971 ±0.325	11.400 ±0.358	— —	9.625 ±0.480	36.50 ±0.25	39.00 ±0.78
Width (mm)	0.454 ±0.008	0.326 ±0.015	0.653 ±0.024	0.980 ±0.068	2.181 ±0.155	3.900 ±0.089	—	4.125 ±0.207	13.50 ±0.56	15.00 ±0.23

the present study in September and October were 25.38 ± 0.42° C, and 16.79 ± 0.13° C respectively.

RESULTS AND DISCUSSION

Egg: A female lays 45 to 62 eggs in 5 to 7 days. Maximum number of eggs are laid on the first two days and successively declines during the ovipositional period. The eggs are laid scattered and tightly glued to the substratum. In the field and laboratory the females are observed to lay eggs on panicles, flower buds and tender capsules.

The eggs are light greenish flat based and round (Fig. 1 a). The dorsal surface is slightly depressed. The chorion of the egg is highly sculptured (Fig. 2). The egg turns dark after two days. The hatching period is 5 to 6 days with 71.43% hatchability. The young larva makes a body size outlet on the dorsal surface to hatch out from the egg (Fig. 1 b). The eggs measured 0.835±0.012×0.454±0.008 mm (Table 1).

Larva: The neonate caterpillars are greenish and active. The body is onisciform with prominent hairs on the dorsolateral region (Fig. 3). It starts feeding on unopened flowers and buds. The I instar larva measures 1.817 ± 0.032 × 0.326 ± 0.15 mm and lasts for 4 days. The II and III instar larvae turn to pale brown and are not active. The dorsal surface setae disappear but small and fine setae are present on the lateral sides. These larvae bore small and tender capsules and last for 3–4 days each (Table 1).

The IV and V instar larvae are dull yellow and sluggish (Fig. 4). The head capsule is very small compared to the body segments and is almost concealed by the prothorax. Five pairs of prolegs are present on III to VI and last abdominal segments. Minute fine setae are present on the lateral surface whereas star-shaped setal basement of secondary setae cover the body dorsolaterally. The last three abdominal segments are flat and trowel shaped. The larvae feed on immature capsules by making a circular hold and consume whole seeds (Figs. 7, 8); seeds of ripened capsules are rejected after some bites on the pericarp. A V instar larva consumes the seeds of 2 to 3 capsules in 24 h. According to SIDDAPPAJI & REDDY (1972) each larva requires 25–27 capsules to attain maturity and the estimated loss ranges from 16–24 per cent of the capsules. The V instar larva measures 11.400 ±0.358 × 3.900 ± 0.089 mm. The total larval

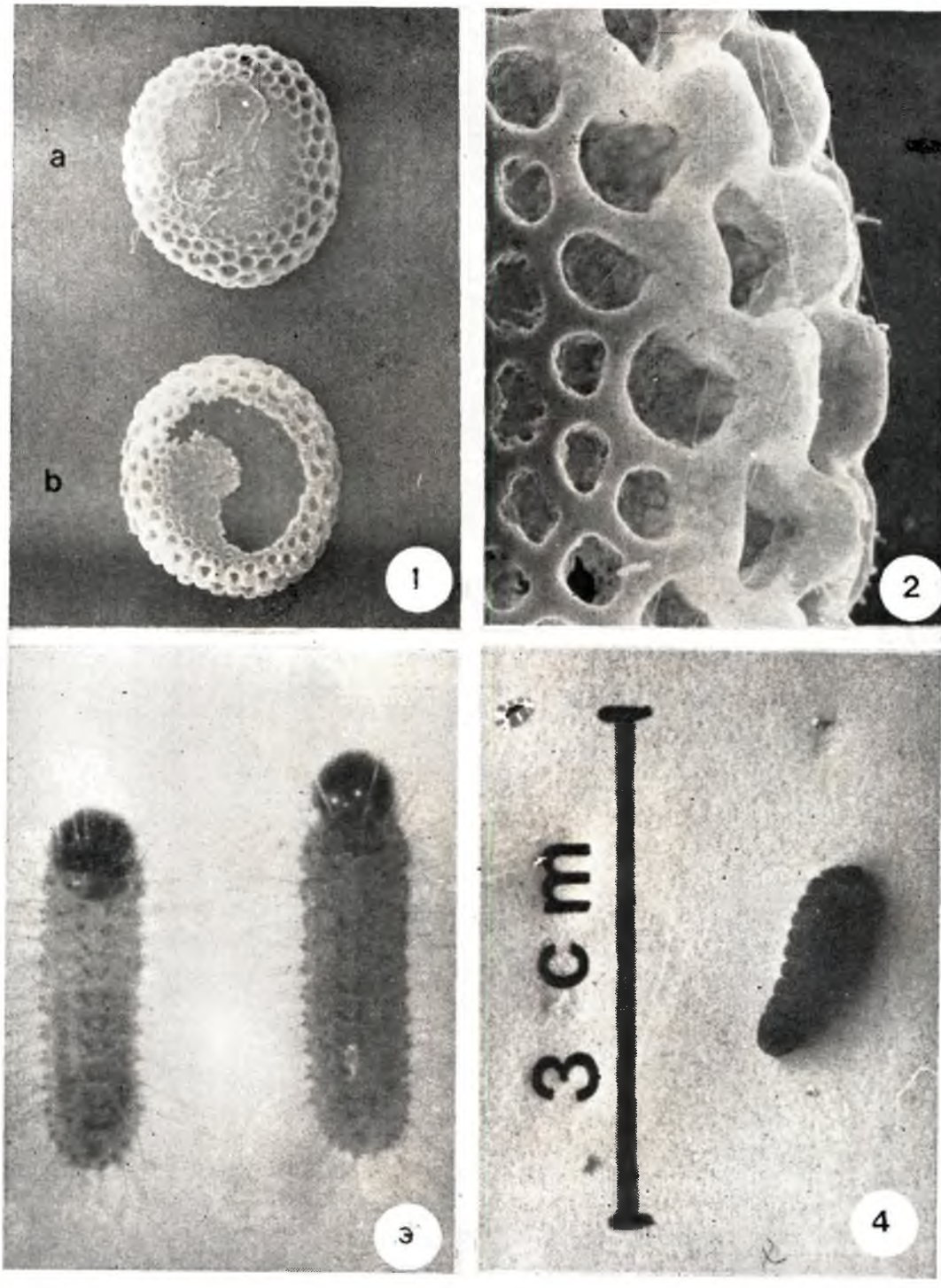
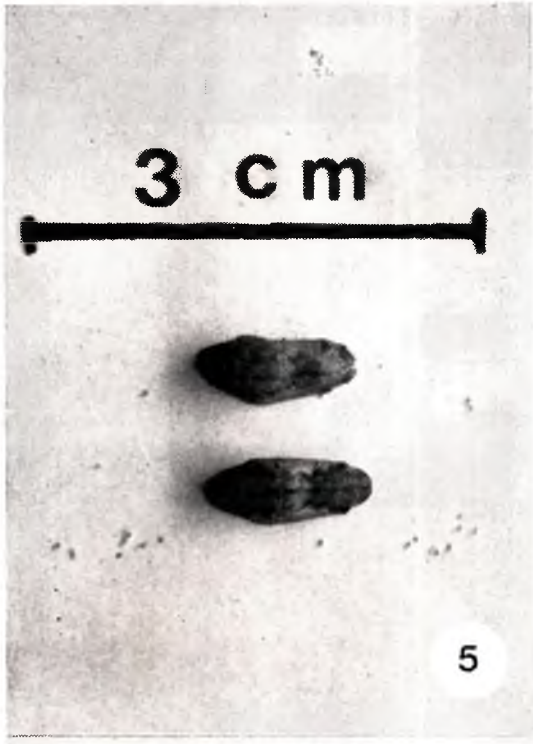
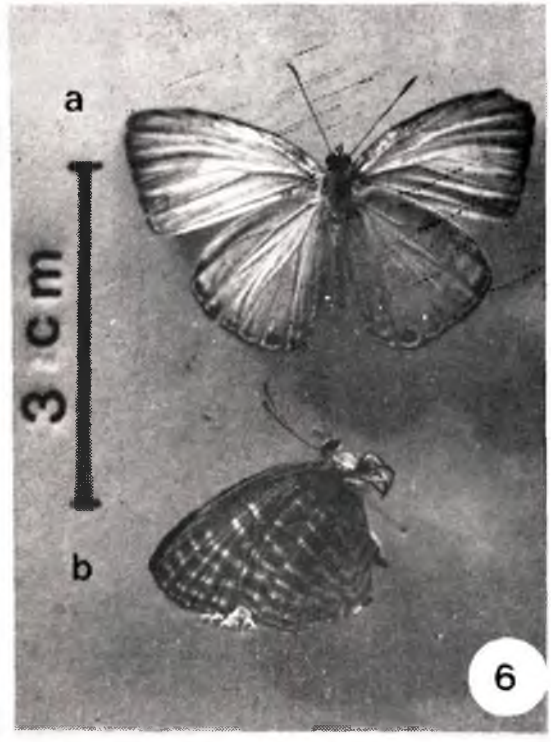


Fig. 1 a: Scanning structure of the egg (40×); 1 b: The egg shell showing the outlet of the larva (40×); 2. Scanning enlargement of the chorion (320×); 3. First instar larvae; 4. Fifth instar larva.





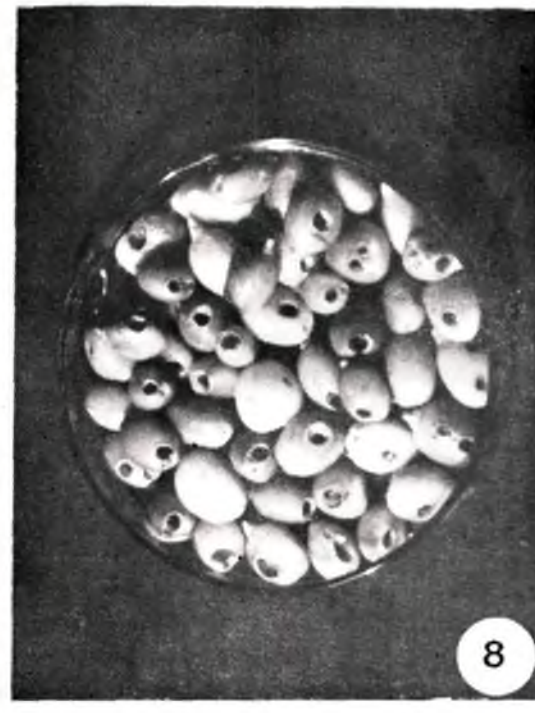


Fig. 5. Pupa; 6 a: Adult butterfly - dorsal view; 6 b: Ventral view; 7. Larva boring the capsule; 8. Capsules bored by larvae.

duration is completed in 20 to 25 days (Table 1).

During the laboratory studies, a maximum mortality of 40% was recorded during the I instar stage and 33% in the II instar probably due to non-availability of suitable food and micro-climate. A mortality of 12.5% was observed during the III instar stage whereas IV instar was free from mortality. During the total larval period, only 50% of caterpillars of I instar could successfully enter into pupal stage.

Pupa : The larva pupates inside the bored capsule or outside in the debris. The prepupal period lasts for 2 days and pupal period for 12–13 days. The pupa is short, naked, smooth, anteriorly rounded and yellowish brown (Fig.5). The pupa measures $9.625 \pm 0.480 \times 4.125 \pm 0.207$ mm. A mortality of 16.67% was noted during the pupal stage.

Adult : The medium sized adult butterfly is an active flier. The upper surface of the wing is metalic blue and bordered with a white thin line and black shade (Fig. 6a). The underside colouration is more sombre with white streaks (Fig. 6b). The hind wings are provided with delicate small tail-like prolongations. The antannae are clubbed and ringed in white colour. A rim of white scales surround each eye. The male butterfly has a wing span of 36.50 ± 0.25 mm whereas that of the female is 39.00 ± 0.78 mm. The longevity of adult females was higher (8–12 days) than that of males (6–8 days) (Table 1). The sex ratio was 1:1.5 male: female.

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BRIEF COMMUNICATION

ASIALEYRODES SAKLESPURENSIS SP. NOV. (ALEYRODIDAE : HOMOPTERA) FROM INDIA

K. REGU & B. V. DAVID
Fredrick Institute of Plant Protection and Toxicology, Padappai, Tamil Nadu, India 601 301

(*Received* 12 *June* 1991)

A species of whitefly collected from the plant *Olea* sp. at Saklespur (Karnataka State) during February 1990 has been found to be new to science and described as *Asialeyrodes saklespurensis* sp. nov.

(*Key words : Asialeyrodes saklespurensis, Olea* sp., Aleyrodidae)

Corbett (1935) erected the genus *Asialeyrodes* for two species of whiteflies *A. lumpurensis* and *A. selangorensis* from Kuala Lumpur, the type species being *A. lumpurensis*. Takahashi (1942) added two species *A. euphorbiae* and *A. multipori* from Thailand and suggested a new combination *A. maesae* for *Pseudaleyrodes maesae* Takahashi from Taiwan and in 1949 he added one more species *A. corbetti* from Riouw Islands. This paper describes a new species *Asialeyrodes saklespurensis.*

Asialeyrodes saklespurensis sp. nov.
(Figs. 1–4)

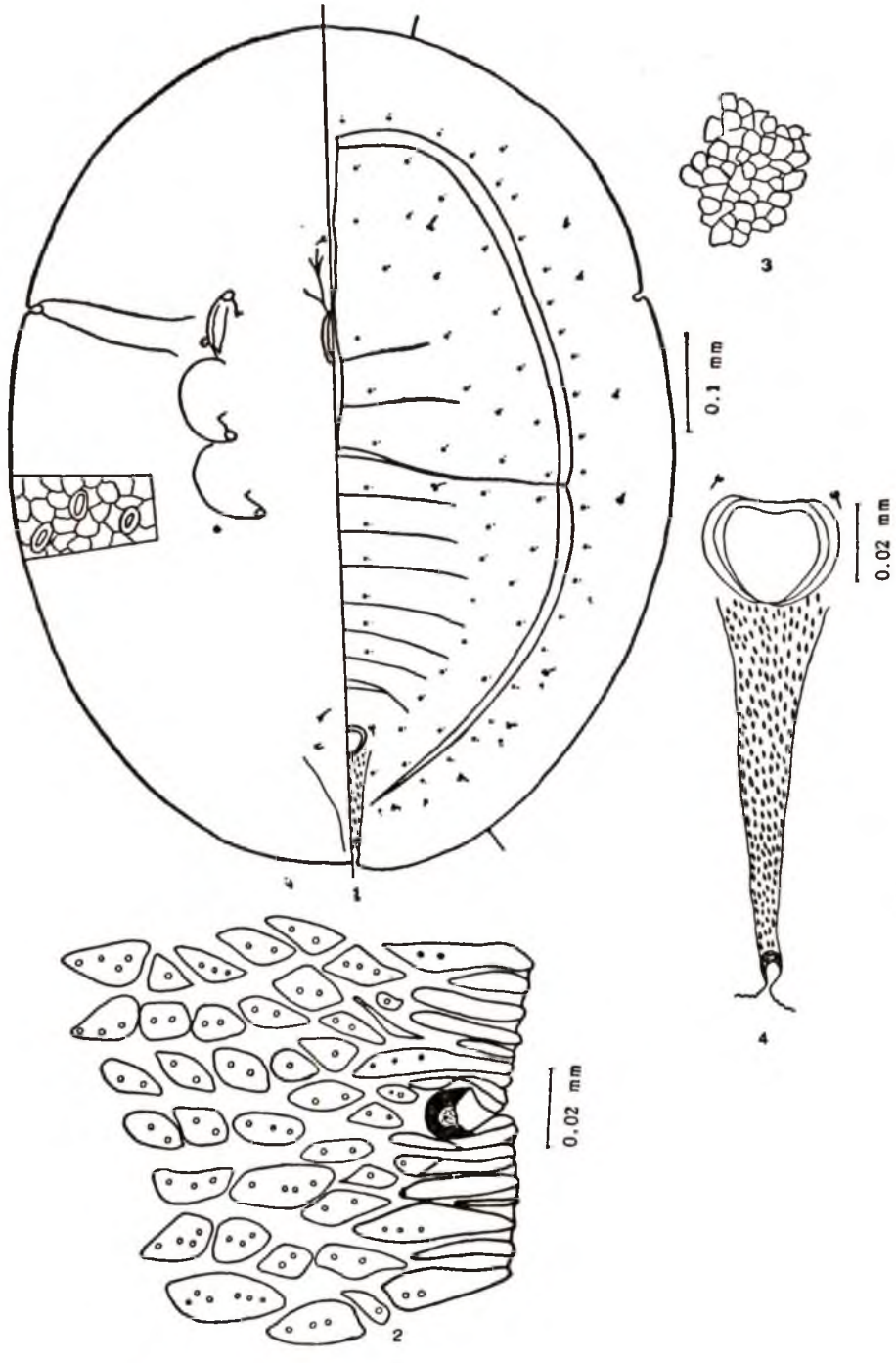
Pupal case: Light brown to dark brown with a thick fringe of wax around margin and a thin layer of powdery wax on dorsum; broadly elliptical, slightly constricted across the thoracic tracheal pores, broadest at the first abdominal segment region; 0.83–1.18 mm long and 0.67–1.00 mm wide; found on the lower surface of leaves singly.

Margin: Smooth, anterior marginal setae 17.5 – 22.5 μm long and posterior marginal setae 20.0 – 22.5 μm long; thoracic and caudal tracheal pores distinct with chitinised rim.

Dorsal surface: Four pairs of setae–cephalic setae 7.5–12.5 μm long, first abdominal setae 12.5–20.0 μm long, eighth abdominal setae cephalolaterad of vasiform orifice 5.0–10.0 μm long. Submargin separated from dorsal disc by a complete furrow; submargin broad, 130.0–182.5 μm wide; longitudinal and transverse moulting sutures reach submargin. A row of 8 pairs of submarginal setae - 3 pairs on cephalothorax (2 pairs on cephalus and one pair on metathorax) and five pairs on abdomen (one pair each on abdominal segments I and V – VIII) 7.5–10.0 μm long. Submargin contains polygonal markings with pores and dorsal disc with irregular or small polygonal markings. Pores and porettes sparsely distributed throughout dorsum.

Vasiform orifice: Small, subcordate, wider than long, 37.5 - 45.0 μm wide and 30.0 – 32.5 μm long; operculum similarly shaped, 25.0–32.5 μm wide and 22.5 – 27.5 μm long, filling the orifice, obscuring the lingula. Caudal tracheal furrow prominent, 92.5 – 150.0 μm long and 10.0–15.0 μm wide with polygonal markings, whereas thoracic tracheal furrows absent.

Ventral surface : Paired ventral abdominal seta 10–15.0 μm long and 32.5–42.5 μm apart. Thoracic and caudal tracheal folds distinct. Stomata - like markings evident; setae at the base of rostrum present.



Asialeyrodes saklespurensis sp. nov. Figs.: 1. Pupal case; 2. Thoracic tracheal pore with submarginal markings; 3. Markings on dorsal disc; 4. Vasiform orifice with caudal furrow.

Host : *Olea* sp. (Oleaceae)

Material examined : **Holotype** : INDIA : KARNATAKA, Saklespur; 4. ii. 1990, Coll. K. Regu. Paratypes : Twelve pupal cases on slides bearing the same details as of holotype and numerous pupal cases in the collections of the senior author.

This species resembles *Asialeyrodes selangorensis* Corbett but differs from that in colour, presence of submarginal setae and markings on dorsal surface.

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Thanks are due to Dr. C. LIVINGSTON, Professor of Botany, Madras Christian College, Tambaram and to Mr. S. JAMES FREDRICK, Chairman, FIPPAT for facilities provided.

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BRIEF COMMUNICATION

FIRST RECORD OF THE WHITEFLY GENUS *MARTINIELLA* ALEXANDER & DAVID (ALEYRODIDAE : HOMOPTERA) FROM INDIA

R. SUNDARARAJ & B. V. DAVID
Fredrick Institute of Plant Protection and Toxicology, Padappai, Tamil Nadu, India 601 301

(*Received* 30 *June* 1991)

Two new species of the whitefly genus *Martiniella* Alexander & David, viz. V. *ayyari* from *Mussaenda* sp. and *M. lefroyi* from *Elatostemma* sp. are described and illusrated. A key to Indian species of the genus has been provided.

(*Key words: Martiniella ayyari, Martiniella lefroyi, Mussaenda* sp., *Elatostomma* sp.)

In 1990 Alexander & David erected the genus *Martiniella* for the species *Aleurotuberculatus canangae* described by Corbett (1935) from Malaya. In the present study two species of the genus, one from *Mussaenda* sp. and other from *Elatostemma* sp., are described in detail. In addition, a workable key to Indian species of *Martiniella* is given.

1. Martiniella ayyari sp. nov.
(Figures 1–3)

Pupal case: Small, white without wax; oval, broadest across the first abdominal segment region; 0.57–0.61 mm long and 0.41–0.42 mm wide; found scattered singly on the under surface of leaves.

Margin: Finely crenulate, 33–36 crenulations in 1 mm; anterior and posterior marginal setae respectively 12.5 μm and 22.5μm long. Thoracic and caudal pores distinct.

Dorsal surface: Two pairs of two segmented setae a pair on cephalic region, 400 μm long and a pair on I abdominal segment, 300 μm long; a pair of submarginal caudal setae, 125 μm long, one on either side of caudal furrow. Marginal narrow area of venter separated from the medain area forming a distinct rim; dorsum smooth, free from granules or dots with sparsely distributed minute pores.

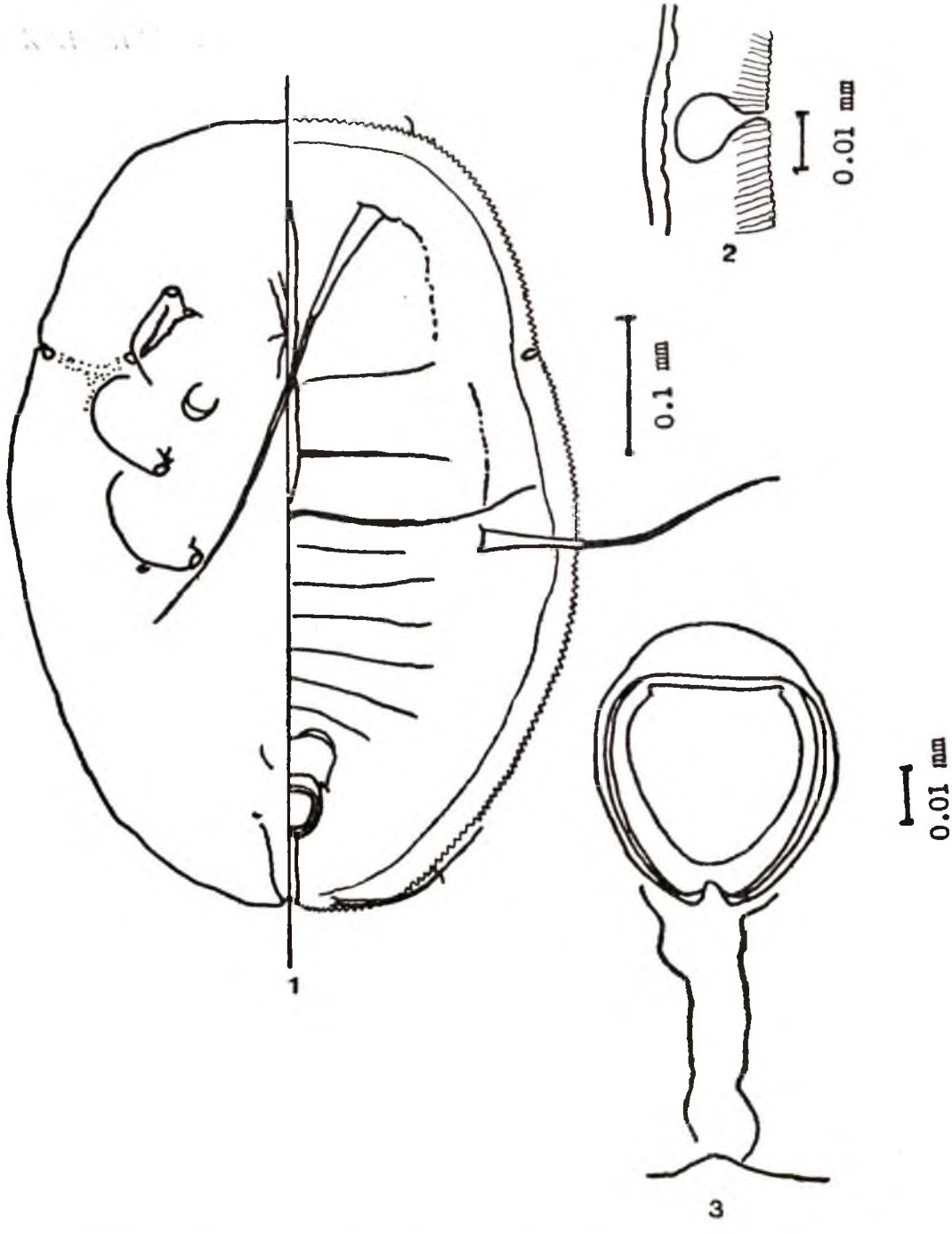
Vasiform orifice: Cordate, notched at the caudal end with its inner lateral walls ridged, longer than wide (50 × 47.5 μm). Operculam as long as wide (32.5 × 32.5 μm), filling the orifice and obscuring lingula. Thoracic tracheal furrows indistint. Caudal tracheal furrow funnel - shaped without tassellations, 52.5–60 μm long and 7.5 μm wide at its caudal end.

Ventral surface: A pair of ventral abdominal setae 12.5 μm long and 32.5 μm apart; thoracic tracheal folds with stipples and caudal tracheal fold lacks stipples.

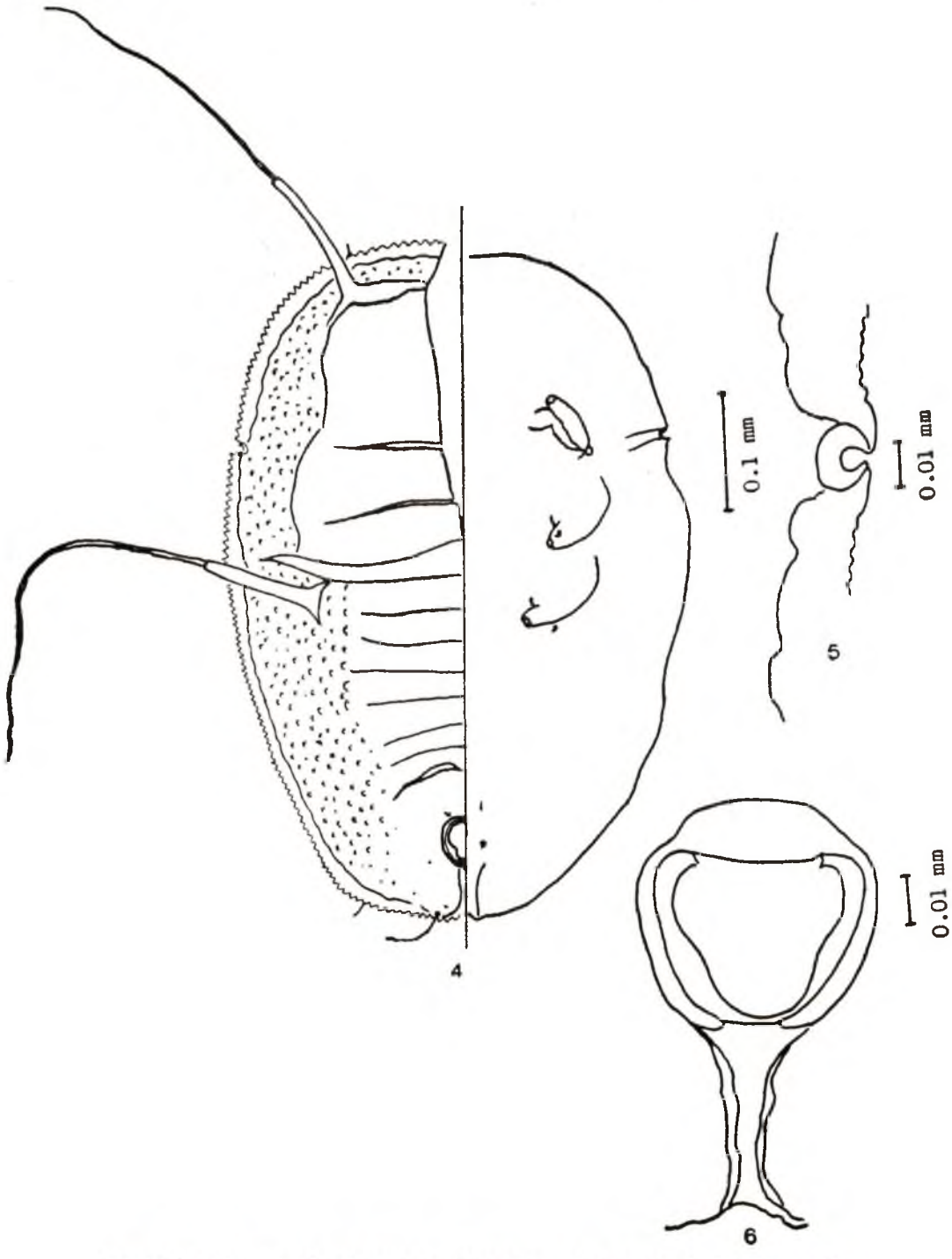
Host: Mussaenda sp.

Marterial examined: **Holotype** INDIA: TAMIL NADU; Padmanabhapuram; *Mussaenda* sp., 4. viii. 1987. Coll. R. Sundararaj in the collection of B.V. David. **Paratypes:** seven pupal cases on slides, bearing the same details.

Deposited in: Systematic Entomology Laboratory, USDA, Beltsville, Maryland, U.S.A.



Martiniella ayyari Figs. 1. Pupal case; 2. Thoracic tracheal pore; 3. Vasiform orifice.



Martiniella lefroyi 4. Pupal case; 5. Thoracic tracheal pore; 6. Vasifrom orifice.

British Museum (Natural History), London; Division of Entomology, Indian Agricultural Research Institute, New Delhi, India, and the Zoological Survey of India, Calcutta, India.

This species comes close to *M. lefroyi* sp. nov. in size, shape and by the indication of thoracic tracheal pore but differs from it by the shape of vasiform orifice and operculum and by the absence of granules on subdorsum.

2. Martiniella lefroyi sp. nov. (Figures 4–6)

Pupal case: White without wax; oval, slightly constricted at the thoracic tracheal pore region; 0.57–0.66 mm long and 0.40–0.48 mm wide; found singly on the under surface of leaves.

Margin: Regularly crenulate, 29–30 crenulations in 0.1 mm; thoracic and caudal tracheal pores distinct; anterior and posterior marginal setae respectively 10 μm and 12.5 μm long.

Dorsal surface: Dorsum with four pairs of setae - two segmented cephalic and 1 abdominal setae 430 μm and 400 μm long respectively, VIII abdominal setae 160 μm long. Dorsum with sparsely distributed minute pores; subdorsum densely granulated; marginal narrow area of venter separated from the median area forming a distinct rim. Cephalothoracic suture indicated.

Vasifrom orifice: Subrectangular, with a distinct notch at the posterior end, 52.5–57.5 μm long and 50–52.5 μm wide; operculum constricted posteriorly, 32.5–37.5 μm long and 35–40 μm wide, filling the orifice; lingula concealed. Thoracic tracheal furrows indistinct. Caudal tracheal furrow funnel-shaped, 40–57.5 μm long and 7.5 μm wide at its pore end.

Ventral surface: Paired ventral abdominal setae 5 μm long and 55 μm apart; thoracic and caudal tracheal folds indicated.

Host: Elatostemma sp.

Material examined : **Holotype:** INDIA; MAHARASHTRA; Mahableshwar, *Elatostemma* sp., 28.iii.1987, Coll. B. V. David. Holotype with B. V. David. Paratypes: Nine pupal cases on slides, bearing the above details.

Deposited in: Systematic Entomology Laboratory, USDA, Beltsville, Maryland, U.S.A.; British Museum (Natural History), London; Division of Entomology, Indian Agricultural Research Institute, New Delhi, India, and the Zoological Survey of India, Calcutta, India.

This new species runs close to *M. ayyari* sp. nov. in shape, size and by distinct indication of thoracic tracheal pores but differs from it by the shape of vasiform orifice and in having granules on subdorsum. It is also close to *M. canangae* (Corbett) in having granulated subdorsum but differs by absence of cephalothoracic and median tubercles on abdominal segments.

KEY TO INDIAN SPECIES OF *MARTINELLA* ALEXANDER & DAVID

1. Margin with 33–36 crenulations in 0.1 mm; subdorsum without granules; vasiform orifice cordate..... *ayyari* sp. nov.

   Margin with 29–30 crenulations in 0.1 mm, subdorsum with granules; vasiform orifice; subrectangular..... *lefroyi* sp. nov.

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Thanks are due to Mr. James Fredrick, Chairman, and Dr. Clement Peter, Head, Department of Entomoloy, Fredrick Institute of Plant Protection and Toxicology, Padappai, for the facilities provided. It forms part of Ph.D. thesis of the first author approved by the University of Madras.

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BRIEF COMMUNICATION

ADDITIONS TO THE INSECT FAUNA ASSOCIATED WITH TREE SPICES[1]

S. DEVASAHAYAM & K. M. ABULLA KOYA
National Research Centre for Spices, Marikkunnu, Calicut, Kerala, India 673 012

(*Received* 5 *May* 1991)

Brief notes on six species of insects recorded for the first time on cinnamon, clove and nutmeg plants in the nursery in Kerala, India are given.

(*Key words :* Cinnamon, clove, nutmeg, new records of insect pests)

The tree spices, cinnamon (*Cinnamomum verum* Bercht & Presl.), clove (*Eugenia caryophyllus* (Sprengel) Bullock & Harrison) and nutmeg (*Myristica fragrans* van Houtton) are mainly cultivated in certain regions of Kerala, Tamil Nadu and Karnataka. These crops are generally free of any major insect pests in the field; however, they are susceptible to a few pests in the nursery. Regular monitoring of these crops in the field and in the nursery at the farm of the National Research Centre for Spices at Peruvannamuzhi (Kozhikode District, Kerala) brought out six new records of insect pests in the nursery. Brief notes on their morphology and the damage caused by them are reported here.

CINNAMON

1. *Conopomorpha* (*Acrocercops*) *civica* Meyr. (Lepidoptera : Gracillaridae)

Larvae infested tender leaves of seedlings. They fed on the tissues in between the upper and lower epidermis leading to drying up of infested portions. Adults had a wing span of 5.0 mm; wings were silvery grey with faint white marks on forewing. During September 1989, 20.2 per cent of the seedlings were infested in a sample of 840 plants. An undetermined species of *Conopomorpha* (*Acrocercops*) has been recorded earlier on cinnamon (Singh *et al.* 1978).

2. *Lopharcha* sp. nr. *halidora* Meyr. (Lepidoptera : Tortricidae)

Larvae infested tender leaves of seedlings. Nature of damage was almost similar to that of *A. civica*; however, the mined areas were larger in size. Pupation occurred within the mined areas. Adults had a wing span of 12.5 mm; wings were blackish brown with faint white marks on the forewigs. The infestation in the nursery was negligible.

CLOVE

1. *Kilifia accuminata* (Sign.) (Homoptera: Coccidae)

Occurred along with *Aspidiotus destructor* with a similar pattern of infestation. The general appearance of mature scales was also similar to that of *A. destructor*, but were smaller (diameter: 1.0 mm). The infestation in the nursery was negligible.

[1] Contribution No. 157 of National Research Centre for Spices, Calicut-673 012.

2. *Aspidiotus destructor* Sign. (Homoptera: Diaspididae)

Observed on one year old seedlings. The scales were distributed on the lower surface of tender leaves. Mature scales were creamy yellow with a semi-transparent circular, slightly convex covering and measured 1.5 mm in diameter. During September 1989, 9.7 per cent of the seedlings were infested in a sample of 300 plants.

NUTMEG

1. *Protopulvinaria mangiferae* (Green) (Homoptera : Coccidae)

Observed on one year old seedlings and grafts. The scales were distributed on the lower and upper surface of tender and mature leaves and also on tender stems. Mature scales were creamy brown, oval and hemispherical and measured 3.0 × 1.75 mm. *P. mangiferae* has been recorded earlier on nutmeg in Malaysia (HILL, 1983). During November 1988, 14.2 per cent of the seedlings/grafts were infested in a sample of 250 plants.

2. *Pseudaulacaspis cockerelli* (Cooley) (Homoptera : Diaspididae)

Observed on one year old seedlings and grafts. The scales were distributed uniformly on the lower surface of tender and mature leaves. Mature scales were wihte, flat and shaped like a fish scale and measured 2.25 × 1.5 mm. The pest infestation was also observed on *M. beddomei*, a related species of nutmeg. During November 1988, 12.4 per cent of the seedlings were infested in a sample of 250 plants.

The infestation of scales on clove and nutmeg resulted in yellow streaks and spots on the affected portions of the leaves. When control measures were not undertaken, severely infested leaves wilted and the plants presented sickly appearance.

ACKNOWLEDGEMENTS

We are thankful to Drs. J. D. BRADLEY, G. W. WATSON and D. J. WILLIAMS of the CAB International Institute of Entomology, London for the identification of the insects.

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BRIEF COMMUNICATION

RECORD OF A NEW PEST, *ARTONA CHORISTA* JORDAN (LEPIDOPTERA: ZYGAENIDAE) OF LARGE CARDAMOM FROM SIKKIM AND WEST BENGAL

SUJATA YADAV NEE CHATTERJEE, ANAND KUMAR & R. NAIDU[1]
Regional Research Station, Spices Board, Dzongu House, Baluwakhani, Gangtok, India 737 103

(*Received* 5 *May* 1991)

Artona chorista **Jordan (Lepidoptera: Zygaenidae) was recorded for the first time as a major pest of large cardamom during a survey carried out in Sikkim and Darjeeling district of West Bengal. The pest infestation ranged from 11 to 62 per cent in different areas. The pest was parasitised by dipteran (11.2 per cent) and hymenopteran (12.5 per cent) parasites in the field.**

(*Key words: Artona chorista*, pest, *Amomum subulatum*)

The large cardamom, *Amomum subulatum* Roxb. (Scitaminae: Zingiberaceae) is a shade loving indigenous crop grown under humid and cold conditions of forests of North Eastern Himalayas. It is a major cash crop of Sikkim which has the largest area of 14,047 ha under cultivation and contributes to about 70 per cent of the total production (3,512 tonnes dried capsules) in India (Subba, 1984).

More than twenty insect species are known to be associated with large cardamom, some of which cause severe damage to the crop (Bhowmick, 1962; Azad Thakur, 1982; Pangtey & Azad Thakur, 1986). During a survey carried out in 1989–1990 and 1990–1991, a hairy caterpillar was recorded as a major pest in some cardamom growing areas of Sikkim viz., Assam Linzey, Dikling, Naitham, Gangtok and Darjeeling district of West Bengal viz., Rango Suruk, Godak and Today. The symptoms of attack and morphology of this pest was similar to the leaf eating caterpillar *Clelea plumbiola* reported earlier from Sikkim (Subba, 1979). The specimens were identified as *Artona chorista* Jordan (Zygaenidae).

The infestation percentage was noted in different areas. The larvae were brought to the laboratory for rearing along with the infested leaves. Four hundred and fifty larvae were kept in 500 ml glass jars (50 larvae per jar) and provided with fresh cardamom leaves daily. In the early stages, the larvae fed on the ventral surface, skeletonizing the leaves. Later, they fed voraciously on the entire leaf leaving only the midribs. They pupated in pale brown silken cocoons on the leaves as well as on the sides of the glass jars. The larval and pupal mortality, emergence, sex ratio and percentage of parasitism was recorded. Five pairs of males and females were kept individually in glass vials (4" × 1") with food (50 per cent honey solution) and without food to determine the longevity of adults. The experiment was conducted at 13.03 ± 2.9°C room temperature and 85.00 ± 8.9 % relative humidity.

The adult moth was black. The males possessed bipectinate antennae while in females the antennae were filiform. The

[1] Director (Res), ICRI, Spices Board, Myladumpara, Idukki, Kerala.

wing span measured 14.00 mm. The larval and pupal mortality during rearing was 27.77 and 28.69 per cent, respectively. The emergence was noted throughout the day from 8.00 AM to 5.00 PM and found to be 57.55 per cent. The sex ratio was 1:1.42 male : female. The average longevity of males was 5.8 days and 1.0 day with and without food, respectively. The females survived on an average of 5.6 days with food and 1.0 day without food. The infestation by the pest was minimum (11 per cent) in Dambyong and maximum (62 per cent) in Assam Linzey. Field parasitism by dipteran and hymenopteran parasites was to an extent of 11.2 and 12.5 per cent, respectively.

Distribution: India: Sikkim: East District-Gangtok, Assam Linzey, Dikling, Naitham, Pangthang, Tadong, Dambyong; West District - Soreng; North District – Dzongu; West Bengal : Darjeeling District - Rango, Suruk, Godak and Today on large cardamom.

Artona catoxantha, a well known pest of coconut and palm trees in South East Asia and *Clelea plumbiola* reported by Hampson (1892) are allied to *Artona chorista.*

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Authors are grateful to Dr. J. D. HOLLOWAY, Commonwealth Institute of Entomology, London and Dr. G. TARMANN, Tiroler Landesmuseum Ferdinandeum Innsbruck, Austria for identification of specimens.

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